The Engineer

LONDON, FRIDAY, NOVEMBER 28, 1941

PUBLIC NOTICES

CITY OF SALISBURY
SOUTHERN RHODESIA

PIPING EQUIPMENT FOR POWER STATION

Tenders are Invited for the SUPPLY, DELIVERY and ERECTION of the above-mentioned EQUIPMENT in accordance with the City Council's specification.

One copy of the specification may be obtained from the Consulting Engineers, Messrs. Merz and McLellan, 32, Victoria Street, London, S.W.1, on or after 8th December, on payment to them of a fee of £5 5s.

Additional copies of the specification may be obtained from the Consulting Engineers in London on payment of £2 2s. for each such additional copy.

Sums paid on any number of copies up to four will be refunded on receipt of a bona-fide Tender.

Tenderers are requested to note that issue of a Certificate of Essentiality for the above plant and equipment is assured by the Southern Rhodesia Ministry for Co-ordination of Supplies.

Sealed Tenders, with all relative documents endorsed to indicate the item to which they relate, must be delivered in triplicate as follows :

(1) Two copies of the original Tender and documents to the OFFICIAL SECRETARY, Office of the High Commissioner for Southern Rhodesia, Rhodesia House, 429, Strand, London, W.C.2, not later than Noon on Monday, 19th January, 1942 ;

(2) One duplicate Tender and documents to Messrs. MERZ & McLELLAN, 32, Victoria Street, London, S.W.1, not later than 24 hours after deposit of the original Tenders and documents with the High Commissioner.

The Council do not bind themselves to accept the lowest or any Tender. 7977

THE SOUTH STAFFORDSHIRE WATERWORKS COMPANY

RIVER BLITHE SCHEME

The Company Proposes to lay about Six Miles of 33in. diameter, Bitumen-lined and Sheathed STEEL MAIN.

Contractors experienced in Main-laying who WISH to SUBMIT TENDERS are INVITED to APPLY for COPIES of the CONDITIONS of CONTRACT, SPECIFICATION, SCHEDULE of QUANTITIES, &c., which will shortly be ready for issue.

Applications should be accompanied by a deposit of Two Guineas, which will be returned on receipt of a bona fide Tender.

FRED. J. DIXON, M. Inst. C.E.,
Engineer-in-Chief.

50, Sheepcote Street,
Birmingham, 15.
24th November, 1941. 7980

THE GOVERNMENT OF SIERRA LEONE
PUBLIC WORKS DEPARTMENT

APPOINTMENT OF ENGINEER

Engineer Required by the Government of Sierra Leone Public Works Department for one tour of 12–24 months. Fixed salary between £600 and £700 a year according to qualifications and experience. Free passages and quarters. Candidates, not over 45, must be fully qualified Civil Engineers, able to undertake the design and supervision of construction of buildings, bridges, &c., preparation of detailed plans and estimates, and taking off of quantities.

Write, stating age and full particulars of qualifications and experience, to the MINISTRY OF LABOUR AND NATIONAL SERVICE, Central Register Branch, Queen Anne's Chambers, Tothill Street, London, S.W.1, quoting E. 338. 7965

GOLD COAST GOVERNMENT RAILWAY

VACANCIES FOR ASSISTANT ENGINEER (CIVIL)

Required for the Gold Coast Government Railway for two tours of 12-24 months, with possible permanency. Salary £475, rising to £840 a year, then, subject to promotion to a vacancy, to £1000 a year. Free quarters and passages.

Candidates, aged 25 to 35, must be Corporate Members of the Institution of Civil Engineers or possess an Engineering Degree recognised as granting exemption from Sections A and B of the A.M.I.C.E. examination. They must have had practical experience on a British Railway and preference will be given to candidates who have also had practical experience in harbour maintenance.

Write, stating age and full particulars of qualifications and experience, to the MINISTRY OF LABOUR AND NATIONAL SERVICE, Central Register Branch, Queen Anne's Chambers, Tothill Street, London, S.W.1, quoting E. 346. 7966

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE
ARRANGED FOR CARD INDEXING
(TABLE OF CONTENTS, PAGE 374)

Further Canadian Locomotive Experiences No. IX (P. 366)
(E. H. LIVESAY) THE ENGINEER, 28 - 11 - 41

Rainbow Bridge, Niagara Falls—No. II (P. 377)
THE ENGINEER, 28 - 11 - 41

A Century of Tunnelling—No. I (P. 368)
(W. T. HALCROW) THE ENGINEER, 28 - 11 - 41

Sorocold's Waterworks at Leeds, 1694 No. II (P. 372)
(F. WILLIAMSON & W. B. CRUMP) THE ENGINEER, 28 - 11 - 41

Machine Tools for Production of Small Arms (P. 379)
THE ENGINEER, 28 - 11 - 41

Contact of Colliding Surfaces (P. 380)
(F. P. BOWDEN & D. TABOR) THE ENGINEER, 28 - 11 - 41

Transport on the Eastern Front (P. 374)
THE ENGINEER, 28 - 11 - 41

BABCOCK VALVE VALUE.

INDEX TO ADVERTISEMENTS, PAGE 63

THE FACT that goods made of raw materials in short supply owing to war conditions are advertised in this paper should not be taken as an indication that they are necessarily available for export.

PUBLIC NOTICES

THE INSTITUTION OF CHEMICAL ENGINEERS

EXAMINATION, 1942

Application Forms (Returnable 15th December, 1941) and particulars of the ASSOCIATE MEMBERSHIP EXAMINATION for 1942, together with the MEMORANDUM on "The Training of a Chemical Engineer," may be obtained from the HON. REGISTRAR, Institution of Chemical Engineers, 56, Victoria Street, Westminster, London, S.W.1. 7848

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS UNLESS SPECIFICALLY REQUESTED.

CHEMICAL ENGINEER—NORTH MIDLANDS. —MANUFACTURERS have VACANCY on Technical Sales Staff for CHEMICAL ENGINEER. Applicants should be University Graduates and have had wide experience of Chemical Manufacturing and Allied Industries.—Address, stating age, experience and salary required, 7962, The Engineer Office. 7962 A

For continuation of Situations Open see page 2.

PUBLIC NOTICES

THE GOVERNMENT OF SIERRA LEONE

APPOINTMENT OF SENIOR AND JUNIOR ASSISTANT DRAINAGE AND IRRIGATION ENGINEER

The Following Staff is Required by the Sierra Leone Government for two tours of 12 to 24 months. Free passages and quarters. An extension of the age limits would be considered in the case of candidates with previous tropical experience.

E. 345.—SENIOR ASSISTANT DRAINAGE AND IRRIGATION ENGINEER.—Salary £800-£40-£920 a year. Candidates, not over 35, must be Corporate Members of the Institution of Civil Engineers or hold an Engineering Degree recognised as granting exemption from Sections A and B of the A.M.I.C.E. examination. They must have had experience in general civil engineering work, including surveying design and construction of reinforced concrete, and preferably sluice and drainage works. Experience of land drainage, reclamation or irrigation work is highly desirable.

E. 339.—JUNIOR ASSISTANT DRAINAGE AND IRRIGATION ENGINEER.—Salary £600-£30-£840 a year. Candidates, not over 35 years, must have passed Sections A and B of the A.M.I.C.E. examination or hold an equivalent university qualification. They must have had at least 3 years' practical experience as Civil Engineers, including surveying, setting out works and preferably land drainage or reclamation. Some experience in the design and construction of small reinforced concrete structures also desirable.

Write, stating age and full particulars of qualifications and experience, to the MINISTRY OF LABOUR AND NATIONAL SERVICE, Central Register Branch, Queen Anne's Chambers, Tothill Street, London, S.W.1, quoting the reference number against the appointment for which application is made. 7963

THE GOVERNMENT OF IRAQ

APPOINTMENT OF FIRST AND SECOND ASSISTANT PORT ENGINEER

The Following Staff is Required by the Iraq Government for the Basrah Port Directorate for three years in the first instance. Free passages. Appointments are not pensionable, but there is a Provident Fund. Iraq dinar 1 equals £1.

E. 340.—FIRST ASSISTANT PORT ENGINEER.—Salary I.D. 90 a month. Candidates, not over 40, must be Corporate Members of the Institution of Civil Engineers or possess equivalent qualifications. They must have had general experience in the design, construction and maintenance of dock and harbour works and should preferably have spent not less than 5 years with a recognised port authority. Some knowledge of road construction and permanent way drainage, together with a general knowledge of electrical and water supply problems, would be an advantage.

E. 341.—SECOND ASSISTANT PORT ENGINEER.—Salary I.D. 65 a month. Candidates not over 35. Qualifications and experience generally similar to the above.

Write, stating age and full particulars of qualifications and experience, to the MINISTRY OF LABOUR AND NATIONAL SERVICE, Central Register Branch, Queen Anne's Chambers, Tothill Street, London, S.W.1, quoting the reference number against the appointment for which application is made. 7964

For continuation of Small Advertisements see page 2

SITUATIONS OPEN, Page 2
SITUATIONS WANTED, Page 2
AUCTIONS, Page 64
FOR SALE, Page 64
MISCELLANEOUS, Page 64
AGENCIES, Page 2
PATENTS, Page 2
MACHINERY, &c., WANTED, Page 2

For Advertisement Rates see First Column Overleaf

CLASSIFIED ADVERTISEMENTS CLOSE FOR
PRESS-NOON WEDNESDAYS

The Engineer
Annual Subscription Rates

(including postal charges).

BRITISH ISLES ...	£3 5 0
CANADA...	£2 18 6
ABROAD	£3 3 0

(except Canada)

"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER each alternate month. Next date, December 26th.

ADVERTISEMENTS.

The Charges for Classified Advertisements are 1/- per line up to one inch—minimum charge, 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

Postal Address,
28, Essex Street, Strand, London, W.C.2.
Teleg. Address,
"Engineer Newspaper, Estrand, London."
Tel., Central 6565 (10 lines).

SITUATIONS OPEN

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

STATUTORY RULES & ORDERS 1940 No. 877

RESTRICTION ON ENGAGEMENT ORDER

CHIEF ENGINEER REQUIRED for Important Midland Firm of Automobile and Aircraft Equipment Manufacturers, engaged entirely on war work. Applicant must have first-class engineering experience and be able to initiate and control the Design, Development, and Testing of a wide variety of products. The position is permanent and carries a substantial salary.—Box No. 403, 19-21, Corporation Street, Birmingham, 2. 7981 A

CONTRACTORS' AGENT REQUIRED for provinces by London Firm. Only men capable of taking full charge of large constructional contracts considered.—Address, stating full experience, salary required and when free to commence, 7939, The Engineer Office. 7939 A

ENGINEERING MANAGER REQUIRED, with first-class Machine Tool and some foundry experience. Good organiser. Work in Midlands employing 600. Salary £720 per annum, progressive.—Address, P3667, The Engineer Office. P3667 A

JUNIOR RATE FIXER REQUIRED for Electrical Switchgear Manufacturers in the Midlands. Good salary and prospects.—Applications, stating previous experience, to be sent to MINISTRY OF LABOUR & NATIONAL SERVICE, Employment Exchange, Banbury, Oxon. 7957 A

MACHINE SHOP SUPERINTENDENT, Fully experienced and used to the Controlling of Labour, REQUIRED for large Engineering Works in the Midlands. Also MACHINE SHOP SUPERVISOR for Night Shift.—Write, stating age, full details of experience and salary required, to 7918, The Engineer Office. 7918 A

MANAGER REQUIRED for Drop Forge of Large Engineering Works in the Midlands Area.—Write, stating age, full experience, and salary required, to 7919, The Engineer Office. 7919 A

MACHINE SHOP SUPERINTENDENT REQUIRED for Light Engineering Factory in Yorkshire. Plant comprises autos, capstans, drills, mills, &c. Work of highest national importance.—Address full particulars age, experience and salary required, 7938, The Engineer Office. 7938 A

MANUFACTURING FIRM, Specialising in components for railway rolling stock, have VACANCY on their Sales Staff for a TECHNICAL REPRESENTATIVE. Applicants should have had an engineering training, preferably with actual railway experience.—Address, giving full particulars of previous experience, age and salary required, 7960, The Engineer Office. 7960 A

OLD-ESTABLISHED FIRM of SECOND-HAND MACHINE TOOL MERCHANTS REQUIRE JUNIOR PURCHASE and SALES REPRESENTATIVE with experience in the trade. State age, experience and salary required. All applications will be treated in strict confidence.—Address, 7978, The Engineer Office. 7978 A

TECHNICAL SALES REPRESENTATIVE REQUIRED. Applicants should be fully qualified engineers and have had extensive experience in the operation and maintenance of Mine Haulages and Winding Engines.—Address, giving age, salary and full details of previous experience, 7961, The Engineer Office. 7961 A

SITUATIONS OPEN

SHEET METAL and PRESS SALES ENGINEER, able to discuss with customers and quote against their inquiries.—Write, stating age, full particulars of experience, and salary required, P3681, The Engineer Office. P3681 A

SUB-CONTRACTS MANAGER (Experienced Engineer) REQUIRED for South Coast Engineering Company. Previous experience essential and good knowledge of Machines, Jigs, and Tools necessary.—Address replies in confidence, 7974, The Engineer Office. 7974 A

THE Post You Are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing Your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for a cost of Four Lines, 4s.; 1s. for each Additional Line. There is no better way of covering so large a field for such a small charge.

SITUATIONS WANTED

ENGINEER, with Experience in Sole Charge as General Manager of Works, active and fit, with acknowledged ability and drive, SEEKS ADMINISTRATIVE POST of RESPONSIBILITY. Salary, £800 to £1000, according to duties.—Address, P3666, The Engineer Office. P3666 B

EXPERIENCED ENGINEER, A.M.I.C.E., M.I.M.E., DESIRES APPOINTMENT duration of war. Recent experience, railway engineering, earthworks, large factories.—Address, P3662, The Engineer Office. P3662 B

ENGINEER (34), 5 Years Works and D.O.' training, 10 years' admin. exp. sales, service, liaison, auto., aero and I.C. marine engines, DESIRES APPOINTMENT, representative or similar, London area.—Address, P3678, The Engineer Office. P3678 B

ENGINEERS' TECHNICAL REPRESENTATIVE REQUIRES CHANGE to work of national importance. Has held management posts as works supt., manager, general manager, charge sales. Experience controlling machine shops, toolroom, press shops, foundry. Specialized on mass production of small and medium size parts. Piecework systems, labour saving devices. Strict disciplinarian. Extremely active and good health (47 years). Exceptionally good references.—Address, P3677, The Engineer Office. P3677 B

ENGINEER, Having Relinquished Successful management of important M.A.P.-controlled firm, SEEKS NEW OUTLET for energy and ability. Not interested in small or easy job, but the wider the scope the better. Over 20 years' comprehensive training and experience in general and electrical engineering and administration, and four-figure salary, indicate the nature of posts held and sought. Experienced factory dispersal and duplication, co-ordination of production from widely separated units, machine tooling, Ministerial liaison. Aged 40.—Address, P3676, The Engineer Office. P3676 B

GENERAL MANAGER.—Engineer, Foundryman, and Accountant, over 25 years' practical experience automobile, aircraft, general mechanical, metallurgical, and foundry work, covering all departments, works, sales, planning, time-study, costs, accounts, &c., A.M.I. Mech. E., A.I.I.A., &c. Minimum salary £1500 a year, plus bonus on results or equivalent.—Address, P3682, The Engineer Office. P3682 B

IF the Man You Are Seeking is Not Amongst those Advertising in this Column, a Small Announcement in the "Situations Open" Column will Quickly and Economically Produce the Right Selection of Applicants, at the same time Eliminating Waste of Effort, Waste of Time, and Waste of Opportunity. The charge is Four Lines or under, 4s.; each Additional Line, 1s.; Box Numbers, 6d. extra, which includes despatch of all replies.

MECHANICAL ENGINEERING DRAUGHTSMAN (37), fully experienced shops and D.O., SEEKS PROGRESSIVE POST, view representing firm after war; must be engaged important war work for release. Please state peacetime product. London district.—Address, P3686, The Engineer Office. P3686 B

MECHANICAL and ELECTRICAL ENGINEER, with 25 years' technical, practical and commercial experience, SEEKS POST as Resident Inspector, Works Manager or Representative for Engineering Concern in South Wales. Home at Cardiff, at present holding post in the London area. Welsh speaking. Age 47 years. Reasonable salary.—Address, P3680, The Engineer Office. P3680 B

WORKS MANAGER DESIRES CHANGE. Age 44; 7 years' articled pupil at Royal Ordnance Factory, 12 years (6 years W.M.) in the manufacture of concrete mixers, batching plants, contractors' plant, &c. Present position, 6½ years as W.M. in the production of heavy trailers, employing 950. Fully conversant latest machine tool practice, ferrous and non-ferrous foundry practice, metal arc welding fabrication. Salary £1000 plus production bonus. South preferred.—Address, P3679, The Engineer Office. P3679 B

AGENCIES

LONDON ENGINEERS with Manager, A.M.I. Mech. E., and imposing offices, SEEK CONNECTIONS with provincial firms. Either agents or liaison, with clients or sub-contractors. Especially power plant and allied lines.—Address, P3675, The Engineer Office. P3675 D

OLD-ESTABLISHED FIRM, with High Technical qualifications and extensive sales connection in North Midlands, WISHES to REPRESENT important ENGINEERING FIRM in preparation for post-war business.—Address, P3657, The Engineer Office. P3657 D

PATENTS

OWNERS of DENTISTRY PATENTS, 286,198, "Improvements in Unit Equipments"; 455,934, "Water Syringe with Heating Coil in Hose"; 455,948, "Water Syringes"; 466,368, "Dry Sterilising Apparatus," wish to MEET all DEMANDS for the UTILISATION thereof and INVITE ENQUIRIES from those competent to assist in commercially EXPLOITING the same.—Write, first instance, Messrs. DICKER, POLLAK, MERCER, TENCH & MEYER, Chartered Patent Agents, 20-23, Holborn, London, E.C.1. 7972 H

PATENTS 269,363, 271,054, 288,031 and 417,065, "Improvements in Dental Units and other Dental Equipment." OWNERS INVITE ENQUIRIES from manufacturers and others competent to assist in EXPLOITING INVENTIONS.—Address in first instance, DICKER, POLLAK, MERCER, TENCH & MEYER, C.P.A., 20, Holborn, E.C.1. 7970 H

THE PROPRIETOR of BRITISH PATENT No. 479,193, relating to "Improvements in or relating to Gas Producers," is DESIROUS of ENTERING into NEGOTIATIONS with one or more firms in Great Britain for the purpose of EXPLOITING the invention, either by SALE of the PATENT RIGHTS or by the GRANT of LICENCES on reasonable terms.—Interested parties who desire further particulars should apply to ALBERT L. MOND & THIEMANN, of 14 to 18, Holborn, London, E.C.1. 7971 H

THE PROPRIETOR of BRITISH PATENT No 490,703, relating to "Improvements in or relating to the Fractional Condensation of Volatile Liquids," is DESIROUS of ENTERING into NEGOTIATIONS with one or more firms in Great Britain for the purpose of EXPLOITING the invention, either by SALE of the PATENT RIGHTS or by the GRANT of LICENCES on reasonable terms.—Interested parties who desire further particulars should apply to ALBERT L. MOND & THIEMANN, of 14 to 18, Holborn, London, E.C.1. 7969 H

THE PROPRIETORS of BRITISH PATENTS Nos. 343,859, 362,381, 365,003, 374,318, 375,517, 376,216, 410,326, 414,005, 433,438, 434,930, 483,983, 489,876, 339,931, 480,968 and 482,546, all relating to "Projectiles": Nos. 372,723, 378,087, 393,105, 392,478, 484,882, 490,196 and 398,052, all relating to "Fuses for Projectiles": Nos. 285,396, 285,399 and 487,534, all relating to "Mortars and the like Guns"; No. 484,346, relating to "Cartridges for Firearms"; and No. 278,659, relating to "Sighting of Ordnance and other Firearms," are DESIROUS of ENTERING into NEGOTIATIONS with one or more firms in Great Britain for the purpose of EXPLOITING the inventions, singly or jointly, either by the SALE of the PATENT RIGHTS or by the GRANT of LICENCES on reasonable terms.—Interested parties who desire further particulars should apply to ALBERT L. MOND & THIEMANN, of 14 to 18, Holborn, London, E.C.1. 7968 H

MACHINERY, &c., WANTED

WANTED, SURPLUS SHIPYARD MACHINERY, comprising Bend Straightening Rolls, Punch and Shears, &c.—Address full particulars, 7967, The Engineer Office. 7967 F

WANTED, ONE 5-TON or 7-TON ELECTRIC OVERHEAD TRAVELLING CRANE, 46ft. span, 400-volt A.C., 40ft. lift.—Address, 7979, The Engineer Office. 7979 F

WANTED, WATER-TUBE BOILERS, Babcock or Stirling only, up to 50,000 lb. evaporation, 200 lb. working pressure or higher.—Address, 7384, The Engineer Office. 7384 F

ALL CLASSES of MACHINE TOOLS WANTED. Cash paid.—NORMAN POTTS, 105, Alcester Road South, Birmingham, 14. 7947 F

ALFRED HERBERT, Ltd., Coventry, PAY BEST PRICES for SECOND-HAND MACHINE TOOLS in good condition by first-class makers.

Write, wire or 'phone, and our representative will call.

'Phone: 88781 (12 lines), Coventry; Telegrams: "Lathe, Coventry." 1002 F

SURPLUS PLANT & MACHINERY REQUIRED TO SATISFY URGENT ENQUIRIES, ESPECIALLY:

Boilers, A.C. Motors, D.C. Motors, Diesel Engines Diesel-driven Generating Sets, Steam Engines, Steam-driven Generating Sets, Colliery Plant, Air Compressors, Turbo and other Pumps, Rubber Plant, Plastic Moulding Plant, Hydraulic Presses, Hydraulic Pumps and Accumulators, Crushers, Cranes, Locomotives, Tanks, Piping, Rails and Wagons, Joists and Steel Buildings, Chemical Plant. Needed for work of urgent national importance. GEORGE COHEN, SONS & CO., LTD. Wood Lane, London, W.12, and Stanningley, nr. Leeds.

PLEASE OFFER US YOUR SURPLUS MACHINES

As Licensed Dealers in MACHINE TOOLS we have numerous inquiries on our books for all types of machines for work of vital national importance. Our representatives will inspect and make spot cash offers for MACHINE TOOLS and SHEET METAL WORKING MACHINERY of every description.

F. J. EDWARDS LTD.,
359, EUSTON ROAD, LONDON, N.W.1
Telephone No.: EUSton 4681
Telegrams: "Bescotools, Norwest, London."

MACHINERY, &c., WANTED

ELECTRIC GENERATOR WANTED, to develop about 250 kW for 400/440 volts, 3-phase, 50 cycles. Complete with starting equipment, if possible. State make, age and full particulars.—Address, 7956, The Engineer Office. 7956 F

REQUIRED URGENTLY, 10ft. by 10ft. Scotch back MARINE BOILER for 150 lb. pressure, new or second-hand.—Write, giving full particulars, to the ADVERTISER, 295, Oldham Road, Salford, Lancs. 7975 F

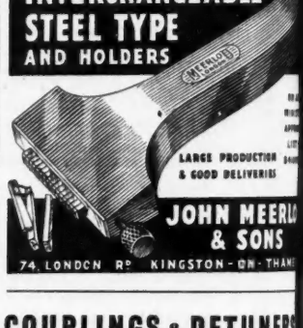
ONE SECOND-HAND SELF-SYNCHRONISING ROTARY CONVERTER SET, [illegible] supply 2820 volts, three-phase, three-wire, 50 cycles; output, 400 kW, 220/230 volts, three-wire D.C. compound wound. To be complete with 3/6-phase transformer and all necessary switchgear, meters, &c., for starting and regulation. Price to include delivery to Erith, Kent.—Full particulars to be sent to the BRITISH OIL and CAKE MILLS, Ltd., Stoneferry Road, Hull. P3683 F

ONE SECOND-HAND 750-kW ALTERNATOR, 750 r.p.m., 400 volts, three-phase, 50 cycles, with direct-coupled D.C. exciter, [illegible] T.P. and N, oil-immersed circuit breaker panel with ammeter, voltmeter (with selector switch 400/230 volts), three-phase, four-wire kW meter, exciter, voltmeter, and ammeter, and exciter shunt regulator. The machine to be constantly rated to develop its full kW output when operating at 0·8 power factor. Price to include delivery to Silvertown, London.—Full particulars to be sent to the BRITISH OIL and CAKE MILLS, Ltd., Stoneferry Road, Hull. P3684 F

URGENTLY REQUIRED for HIRE or PURCHASE, 5-Ton STEAM LOCOMOTIVE SHUNTING CRANE, with buffers, standard gauge, jib 30/35ft.; must be in first-class condition and ready for immediate work.—KING and LAHY (1928), Ltd., Coborn Works, Letchworth, Herts. 7983 F

For continuation of Small Advertisements see page 64

Vertical Milling Machine all geared, hardened and ground throughout, ball and roller bearings, swivelling head, 30"x8" Table. HENRY MILNES LIMITED, Machine Tool Works, Ingleby Street, BRADFORD



COUPLINGS & DETUNERS FOR ALL PURPOSES
THE WELLMAN BIBBY CO., LTD.
VICTORIA STATION HOUSE, VICTORIA STREET, LONDON, S.W.1
Telephone: Victoria 7752.

HAMWORTHY
PUMPS & AIR COMPRESSORS
THE HAMWORTHY ENGINEERING CO., Ltd., Poole, Dorset
Branches:
30, Lynwood Drive, Worcester Park, Surrey. Tel.: Derwent 6[illegible]
118, Queen Street, GLASGOW.

OIL SHALE
The DAVIDSON ROTARY RETORT
A second Battery of these Retorts has been installed by the New Consolidated Gold Fields Ltd
PATENT RETORTS, LTD.,
No. 5, VICTORIA STREET, LONDON, S.W.1.
'Phone: Victoria 1960.

[illegible] & METCALFE
Specialities:
INJECTORS of all classes
ROMILEY RD. MANCHESTER

A Seven-Day Journal

The Shipbuilding Employers' Federation

At the annual general meeting of the Central Board of the Shipbuilding Employers' Federation, which took place at Carlisle on Friday, November 21st, Mr. H. B. Robin Rowell, a director of R. and W. Hawthorn, Leslie and Co., Ltd., of Hebburn-on-Tyne, was elected President for the coming year in succession to Mr. J. M. Ormston, the shipbuilding manager of Vickers-Armstrongs, Ltd., of Barrow-in-Furness. Mr. Louis V. Dunlop, the general manager of Harland and Wolff's Govan Shipbuilding Yard, who was already a Vice-President, now becomes the Senior Vice-President, and the new Vice-President appointed is Mr. F. E. S. Beavan, the manager of the Barry Graving Dock and Engineering Company, Ltd., of Cardiff. Mr. A. L. Cochrane, the joint managing director of Cochrane and Sons, Ltd., of Selby, was elected Chairman of the Conference and Works Board, with Mr. F. W. Knight, a director of Mills and Knight, Ltd., of London, as Vice-Chairman.

Society of British Aircraft Constructors

At a Council meeting held immediately after the recent twenty-fifth annual general meeting of the Society of British Aircraft Constructors, Mr. A. F. Sidgreaves was elected the new President of the Society. He succeeds Sir Frank Spriggs, who has been President since July, 1939. Mr. Sidgreaves is the managing director of Rolls-Royce, Ltd., chairman of Bentley Motors, Ltd., and a director of Rotol Airscrews, Ltd. He is fifty-nine years of age. He began his career in the works of D. Napier and Son, Ltd, formerly motor-car, and latterly aero-engine, constructors. He served for some time with the Royal Naval Air Service and the Royal Flying Corps in the war 1914–18, and later joined the production side of the Air Ministry. After the war he rejoined the Napier Company. He moved to Rolls-Royce, Ltd., in 1920, and has been managing director of the company since 1929. Other appointments include Mr. J. D. North, the managing director of Boulton Paul Aircraft, Ltd., who was elected Vice-President (Aircraft) in succession to Mr. F. Handley Page; and Mr. C. C. Walker, the technical director of the de Havilland Aircraft Company, Ltd., who was elected Vice-President (Engines) in succession to Mr. H. J. Thomas, of the Bristol Aeroplane Company, Ltd. Mr. R. H. Dobson, a director of A. V. Roe and Co., Ltd., was again elected Honorary Treasurer of the Society.

British Standards Institution

At the meeting of the General Council of the British Standards Institution, which was held on Monday, November 10th, 1941, it was announced by the Chairman, Sir Percy Ashley, that it had been decided that, in view of the continuing expansion of the work of the B.S.I. and the development of its relations with Government Departments and with standardising authorities overseas and international bodies, an Executive Committee with a whole-time Chairman should be appointed to keep all the activities of the Institution under review and consider and report to the General Council from time to time as may be necessary. The Executive Committee consists of the Chairman of the General Council, *ex officio*; a whole-time Chairman who shall not, *ex officio*, be a member of the General Council; the Chairmen of the Divisional Councils; the Chairman of the Finance Committee; the Chairman of the Mark Committee; a representative of the Department of Scientific and Industrial Research; a Government representative appointed if the Government so desires and in such manner as it deems appropriate; a nominee by the Institution of Civil Engineers on behalf of the Founder Institutions of the original Engineering Standards Committee; and not more than three co-opted persons with experience of industry and of the work of the Institution, who shall hold office for three years. Mr. C. le Maistre was appointed the first whole-time Chairman of the Committee, and subsequent appointments to the office will be made by the General Council after hearing the recommendation of the Executive Committee. Mr. P. Good was elected Director and Secretary of the Institution. The Executive Committee, it may be noted, replaces the Chairman's Advisory Committee.

Care and Maintenance of Contractors' Plant

In a Journal note of October 17th we summarised the provisions of the new Order of the Ministry of Works and Buildings covering the rates of hire of building and civil engineering contractors' plant. A further step which has just been taken by the Ministry concerns the care and maintenance of such plant when not in use. In order to provide information about such plant it has asked contractors and plant hiring firms to return as soon as possible full particulars of idle plant, together with any shortage of spare parts. It is also undertaking the task of seeing that contractors' plant does not remain idle, and that it is used to the fullest advantage. The Ministry will advise the Ministry of Supply as to what types of new plant shall be manufactured and will issue purchase permits, each case being decided on its merits. The large units of plant have, it is understoood, been in great demand throughout the year, which has meant that they have been more or less fully employed except when under repair. Some plant has, however, been kept idle owing to its being left on a site longer than was necessary or immobilised, either because it might be needed or because it was in need of spare parts. The Ministry hopes that the action it is now taking will put an end to idle plant and ensure that all plant is used to its full extent on important national work.

Waste Paper Salvage

The response to Lord Beaverbrook's appeal for 100,000 tons of waste paper has been widespread, and a great proportion of the quantity required has been collected. It is essential, however, that there be no slacking off in the effort to produce more and more waste paper for the war effort. The daily and the technical press have both taken up this matter in real earnest, and good results are expected to follow the campaign which started some time ago. Shipowning, shipbuilding, marine, and general engineering firms have been exhorted to spare no effort in clearing out old documents, correspondence, catalogues, drawings, etc. We, The Engineer, have ourselves contributed several tons of waste paper, and our search for more is not being slackened. During the past week or so the recently formed Waste Paper Recovery Association, in collaboration with the Waste Paper Merchants' Association, has sought to have amended the regulations which hamper the masters of merchant ships from landing quantities of waste paper from their holds and not dumping it at sea. At the present time such waste paper is regarded by the Customs Authorities as an import and is subject to import regulations. The London Port Authority regards paper unloaded on a quay as an unusual fire risk, and there are difficulties in meeting the expense of special barges for unloading unspecified quantities of paper. It is to be hoped that these difficulties may speedily be overcome. By a new Defence Regulation recently issued by the Board of Trade, a company is protected from any liability in respect of the destruction of transfer deeds of its securities at any time not earlier than three years after the transfer had effect, so long as the officers of the company act in good faith and have at the time no notice of any claim to which the transfers may be relevant. The new regulation applies to documents transferring the company's shares, stock, bonds, debentures, and debenture stock. The Board of Trade expresses the hope that directors will take full advantage of the protection which is afforded by this new regulation and will make available as waste paper the accumulation of transfer deeds which hitherto it has been the practice to retain for long periods.

Control of Machine Tools

The Control of Machine Tools (Electrical Equipment) (No. 1) Order, 1941, concerns electrical equipment for machine tools and its purpose is to introduce a measure of standardisation for such equipment in order to facilitate flow of production. The Order provides:—First, that all such electrical equipment manufactured in the United Kingdom after January 1st, 1942, shall comply with British Standard Specifications; secondly, that indicating instruments shall not be fitted unless they are essential to the efficient operation of a machine tool; thirdly, that electric supply authorities shall not refuse to supply electricity to users requiring to start direct-to-line on a three-phase system, a motor of a capacity not exceeding 5 H.P., or requiring to use on such a system a squirrel-cage motor of a capacity not exceeding 30 H.P.; fourthly, that no person shall, by virtue of any contract, be entitled to demand delivery of electrical equipment produced by a specified maker or of a specified brand, or to require the equipment to be subjected to any test other than is necessary to establish compliance with British Standard Specifications. Tests required by the machine tool makers are excepted from this provision. The Order does not apply to electrical equipment for use on board any ship or vessel. Trade inquirers can obtain further information from the Director of Industrial Electrical Equipment, Machine Tool Control, Ministry of Supply (Code V.A.), 35, Old Queen Street, London, S.W.1.

Payment by Results in the Building and Civil Engineering Industries

In a joint memorandum which was issued by the Minister of Works and Buildings and the Minister of Labour last week it was announced that the Government has decided to extend the principle of payment by results to the maximum extent on all sites scheduled under the provisions of the Essential Work (Building and Civil Engineering) Order. The following operations and trades will now be subject to payment by results:—Machine excavation, excavation by hand, stone hardcore, concrete mixing and placing, and all recognised civil engineering operations, pipe-laying, brickwork, carpentry and joinery, hutting, plastering, painting, and glazing. Additional schedules covering other operations are to be issued at a later date. The executives of the unions in the National Federation of Building Trades Operatives have agreed to play their part in guiding policy on the application of payment by results. This decision of the operatives to co-operate in the carrying out of the further extension of the bonus principle, means that the Ministry of Works can now appoint an official panel of both employers and operatives to advise it on all matters which in future may arise out of the administration and working of the extended system of payment by results. In so far as the new scheme affects branches of the industries which are at present remunerated solely on a time rate basis, the adoption of the principle of payment by results will constitute a recognised "change of practice" and will be operative only for the period of the war, unless and in so far as it may be continued by joint agreement.

Further Canadian Locomotive Experiences

By EDWARD H. LIVESAY

No. IX

(*Continued from page 349, November 21st*)

FAST TRAINS.—MONTREAL-OTTAWA, C.P.R.

WHEN two important cities lie only a little over 100 miles apart, a good train service may be expected to serve them, and some of the trains are likely to be fast. This is true in Canada as in England, but in both countries road transport has cut into railway preserves considerably, and in Canada at least has resulted in fewer trains running between large urban centres than would be the case if road competition were non-existent. Montreal has a population of over a million, and Ottawa, the capital city, something less; yet, though there are three rail routes connecting them, two Canadian Pacific and one Canadian National, a combined total of seven or eight daily trains in each direction gives all the accommodation needed. Most of these are stopping trains, some calling at every station, including those of the "flag" sort—"halts"—and when this is so the average speed is so very moderate that it is hardly worth figuring out. With such trains a cowcatcher in front is really superfluous; it is a work of supererogation, as Mr. Micawber would have said. It should be put at the other end, to prevent cows overtaking the train, climbing on board and biting the passengers. (Not mine—Mark Twain.) Both companies, however, stage a fast evening train from Montreal, reaching Ottawa in a little over two hours, and an early morning train of much the same order in the opposite direction. These are not special shuttle services between Montreal and Ottawa only, but incidentally accommodate these cities when at the eastern end of their transcontinental journeys. When they are operating over this division they are among the fastest trains in Canada. This article deals with those running over Canadian Pacific metals and describes the locomotive work called for, as seen from the cab.

The two C.P. Montreal-Ottawa lines run north and south of the Ottawa River respectively, the former being 120 miles long and the latter, the one coming into this account, 111. It is known as the Short Line, and its Montreal terminus is Windsor Station. The first 23·7 miles to Vaudreuil—named after the French Governor of Canada when Wolfe captured Quebec—are double-tracked, the remainder being single; gradients are fairly frequent, though there is nothing very long or severe, as the route is practically a "water-level" one. I cannot give them, Profile Books being unknown in Canada, which explains why most of my gradient figures on this side of the Atlantic are apt to be of the "by guess and by God" order. Curvature is plentiful over much of the route, and is easier to gauge than inclination, even in the absence of exact figures. In daylight you can see it coming, and prepare to meet it; after dark a stagger means moderation, a dive from one side of the cab to the other means severity—it is sharp, primitive, but indicative. There were a good many recordings made in this way during these two runs. The "oil-can oscillation-meter" used between Dundee and Aberdeen on L.N.E.R. "No. 4793," of blessed memory (THE ENGINEER, October 13th, 1939), would never have worked between Montreal and Ottawa. Too much time would have been occupied in resetting it.

The engines concerned were "Nos. 2826" and "2810," of the 4–6–4 "2800" class, that has come into these articles before, so I need say little about them, merely reminding the reader that they have cylinders 22in. by 30in., drivers 6ft. 3in., 5501 square feet of heating surface, an 81 square foot grate, and 275 lb. pressure. Their tractive effort is 45,000 lb. and total weight 294 tons. Neither engine was booster equipped.

"Train No. 7" pulled out of Windsor Station at 8.15 p.m., headed by engine "No. 2826," in charge of Engineman McNeely and Acland. It is actually one section of "The Dominion," with Vancouver as its ultimate destination, 2882 miles distant and joins the Toronto part at Sudbury, as described in THE ENGINEER of May 30th last. The load was about 850 tons, eleven cars, some of them heavy sleepers. All trains stop at suburban Westmount and Montreal West so real running only begins at the latter point, 4·7 miles from the Windsor start; the station was left at 8.30 p.m., three minutes late, in the warm, gathering dusk of a fine evening. In the absence of a booster there was a trace of slipping; nevertheless, the starts were good, under a full head of steam, and acceleration was rapid. I anticipated roughish riding, from various indications, which included that too familiar box-pound; "No. 2826" had not been shopped for a long time. The anticipation later turned out to be correct. Montreal had sweltered that day under a 95-in-the-shade heat wave, so every opening in the cab was thrown wide to allow entry of a strong side wind, which made our progress noisy, and talking laborious. Once over the Ottawa River, the speed rose rapidly to 75 m.p.h.; the spreading lights of Montreal became more scattered, thinned and disappeared as the train ran along the double track to Vaudreuil, with the C.N. paralleling it, a stretch over which racing has been known to take place between the rival trains. This is frowned upon officially, I believe. I was told to look out for the C.N. "Continental Limited," which leaves Bonaventure Station, also Vancouver-bound, at about the same time "The Dominion" leaves Windsor. It might keep us company for awhile, McNeely said, but it failed to show up—or more likely, had already gone ahead. But I did not suggest this; I have learned tact and diplomacy in the cab, and how to watch my step! Vaudreuil was reached at 8.52, the 19 miles from Montreal West having taken 22 min., 51·8 m.p.h., and a restart made at 8.53, five minutes late.

By this time darkness had fallen, and, as usual, notetaking became more difficult, in spite of an electrically lit cab. Things were made no easier for me by the fact that "No. 2826's" action was getting somewhat turbulent, and the faster she went the more boisterous it became. On a hard-riding engine I can never write sitting down; it is always necessary to stand up and get some spring in my knees whenever paper and pencil have to come together, and so it was on this occasion. Once or twice they refused to coincide at all; at other times the result conveyed nothing to me whatever. Colour-light block signals are installed as far as Rigaud, after which they are automatic; they showed up very well indeed. Curvature, frequent after the single track had been entered at Vaudreuil, was negotiated as gently as possible; otherwise, as McNeely explained, the people in the sleepers behind

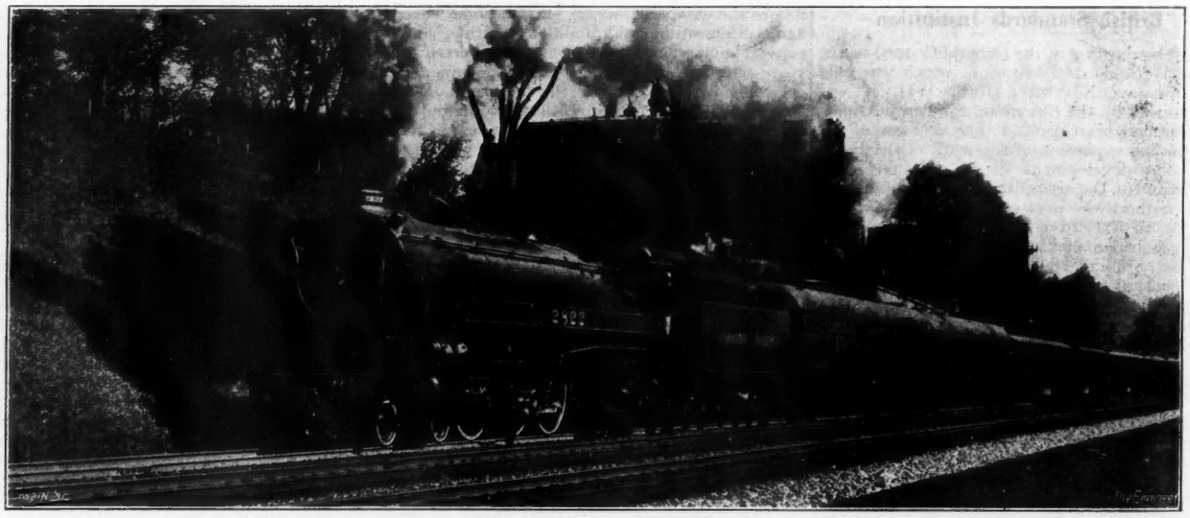


FIG. 32—EXPRESS LEAVING WINDSOR STATION, MONTREAL

would raise Cain. I could not help thinking that if the sleepers were riding anything like the engine their occupants would be fully justified in raising a considerable amount of Cain—his whole corpse and the coffin as well. In fact, "No. 2826" was working fairly hard, at high speed, with a by no means insignificant load, which brought out the fact that a little attention to the running gear would soon be in order.

There was quite a steep gradient up to Hudson Heights, I believe the heaviest on the Division, and Oka Monastery was dimly sighted across the Lake of Two Mountains; it was founded in the seventeenth century and is still doing business at the old stand. Shortly after we stopped for a minute at Vankleek Hill, getting away again at 9.33, three minutes late. The 34 miles from Vaudreuil had been covered in 39 min., 52·3 m.p.h. "No. 2826" was beginning to hit the high spots, as they say out here. Allowing for careful negotiation of curves, that the queasy occupants of berths might not arise in wrath and go scalp hunting, elsewhere the speed was generally around 70 and sometimes more. McNeely opined that it was "a young man's job—you've got to be on your toes all the way—it's a hard run." So it appeared. It even kept me on my toes, and would have put me on something else once or twice if I had not watched out. Yet the throttle was seldom more than two-thirds open, with 25 per cent. cut-off. The "2800s" are fine engines, well suited to a variety of work, from freight to express.

We had been a little behind time at Vankleek Hill, and in making this up miles began to be reeled off in 45 sec., 80 m.p.h., along the straights. An entry, nearly undecipherable, reads: "Riding naturally pretty rough—hardly possible to write even standing—high speed again between Plantagenet and Bourget—got back on time six miles from Ottawa." So, nearing the city, "No. 7" slowed down, crossing the Rideau Canal and proceeding cautiously through the suburbs to a stand in the Union Station at 10.25 p.m., dead on time. The 53·7 miles from Vankleek Hill had taken 52 min., nearly 62 m.p.h., and the whole distance from Montreal West, 106·6 miles, with two stops, had been covered in 115 min., making the average 55·6 m.p.h.

My notes of this run are not very full, but darkness always makes observation difficult and one misses much that daylight would reveal. I went on with the engine and its courteous crew a couple of miles farther, across the river to Hull, which is in the Province of Quebec—Ottawa is in Ontario. It was reached by a circuitous route skirting both cities, the brightly lighted Parliament Buildings standing boldly on rising ground to the left. There was evidently a late session going on, let us hope to the benefit of the country's war effort. I was spending an all-too-short night at the enginemen's bunk-house, as I should have to be up with the lark next morning, to catch the early return train to Montreal. Besides, I wanted to compare it with corresponding British accommodation, once sampled at Toton! Verdict: Toton easily holds its own, but Hull quite good enough for anyone used to roughing it, and who has no objection to locomotives blowing off and blowing down just outside his bedroom all night. Nothing seemed to worry me, anyway.

"Up rose the sonne, and up rose Emilie," sang the knight in the "Canterbury Tales." At 5.30 a.m. of a glorious summer day I followed Emilie's example, as I had been told that the second section of "Train No. 2" would be taking me back to Montreal, and it pulled out at 6.50. Poring over the time-table, it looked to me much like "Train No. 8," which also leaves at that ungodly hour—apparently "No. 2" should have been nearly in Montreal by that time. But I was told to hold my horses—normal train working had been disrupted the day before by a wreck at Tripoli, north of Lake Superior, the outcome of a dispute between a freight and eastbound "No. 2," as to which had the right of way over a single track. As neither would give in, the result was naturally a nasty mess—there is a moral in this. It was made clear to me that, however much my train might look like "No. 8," it was positively the second section of "No. 2" running several hours late, and I could stop worrying—it was on the metals again anyway, and was expected to stay there, with a bit of luck.

Outwardly expressing satisfaction, yet inwardly not entirely at ease—I was riding the engine, there was a lot of single track to navigate, and "No. 2" seemed an unfortunate train—I boarded engine "No. 2810" outside the roundhouse, finding Engineer Dickson and Fireman McCurie in the cab. A brief look round showed a more or less standard "2800," but with one or two little individualities, such as deflector plates (blinkers), hand-operated reverse—rather unusual, this—and an alligator crosshead on one side with a "Laird" on the other. Mr. Bowen, kindly explaining, says: "It was put on for experimental purposes some years ago, as there was an agitation for the use of a 'Laird' crosshead on one section of the road, and as a result of tests made on this particular engine and a few others we eventually adopted the 'Laird' type crosshead on all new power, built in the last few years. However, I would say that even the 'Laird' type crosshead of the design we are now using has disadvantages which we are trying to improve on some of the later engines."

Dickson predicted a rough trip. "What, another? I had a bit of a shaking yesterday!" "Well, your luck's out—you're in for some more to-day!" "Why, what's the matter with this thing?" "Oh, nothing particular—just wants a bit of an overhaul, that's all." It seemed that this was not Dickson's favourite engine, and so naturally it had its little failings. His regular engine, now—ah, that was quite another affair! (How often have I heard this sort of thing!) *That* was the *ne plus ultra* of locomotives—we should just have to make the best of this box of tricks, and chance it. Assuring him that I could take it, "No. 2810" moved away across the Ottawa with eight coaches. A spot was pointed out where Champlain camped in 1500-and-something; he would have difficulty in recognising the site in its present guise of a manufacturing centre, dotted with belching chimneys under a pall of smoke. After Hull, another river crossing, with the Parliament House looking very beautiful in bright sunshine, among green lawns, gardens and trees, the War Memorial in the foreground. A "cut-and-cover" way leads into the Union Station, which is alongside the Rideau Canal, the whole setting being very fine. The story of the Rideau Canal is historically interesting, reminding one that Canada is not entirely new, and has roots going back into a lengthening past. It was built by the British Government after the war of 1812–14, to provide an additional waterway from Montreal to the Great Lakes, far enough away from the St. Lawrence to be safe from interruption should hostilities be renewed at any time. Construction was carried out by British soldiers under Colonel Bye, of the R.E., the route following a chain of fifteen lakes, which, with a few connections and locks, made a waterway 126 miles long between Ottawa and Kingston, on Lake Ontario. The work was done very substantially, the limestone masonry of the locks looking as sound to-day as ever. The canal was completed in 1832, at a cost of £1,000,000. Labour was cheap in those days.

The start from Ottawa was delayed by special orders and station work due to the wreck, the train leaving at 6.56 a.m., six minutes late, with ten coaches, say, 775 tons. The first 50 miles or so were through flat country, with long straights, over which the high-speed running had been done the day before, which was now being repeated; it was generally over 70, and upwards of 80 at times. The action was as Dickson had foreshadowed. It was his first run after holidays: "This will knock all the good out of me," he complained. "Why, this isn't anything very terrible," I said. "It's a bit rough, but yesterday's was worse." "Worse! What the heck did they say was the matter with '2810,' then?" "Tight wedges." This excuse brought derisive laughter, though I do not see why—tight wedges might have had a contributory effect, I should think—among other assorted items! Both engines were rough, undoubtedly, but "No. 2810" was not especially culpable. Basically the cause was the same; they needed shopping, and have no doubt had it long ere this.

Level crossings came into the picture, of course—they are never long out of it in Canada and the States. Approaching one near Plantagenet, on a fine straight very tempting for high speed, with a house close to both track and crossing, Dickson said he had hit a tar-laden tank truck there once, plastering the contents all over house and orchard, some of the apple trees suffering so much from a baptism approximating total immersion that they had to be cut down. The remains of the truck were carried several hundred yards on the pilot (cowcatcher) to a bridge over a little stream, where the train came to a stand. I looked at the scene, picturing it all, thankful for the absence of a tank truck that day. Crossings are not gate protected in Canada outside the cities—and by no means always there. Just beyond this crossing a siding was pointed out as having been one of the Royal train's night resting places, my informant being one of the drivers on that famous journey. The Vankleek Hill "flag" stop followed, at 7.47, O.T., lasting only a brief thirty seconds. The six minutes' late start at Ottawa had been made up, and the 53·7 miles covered in 51 min., at an average speed of 63·2 m.p.h., a little faster than had been done over the same stretch the day before.

Getting away again, and crossing the Ontario-Quebec border at Rigaud, the mountain of the same name with its great cross on the summit very prominent, the train was brought down to walking speed at Choisy siding to allow time for "Train No. 503" to enter at the other end. Vaudreuil, passed non-stop at 8.29—34 miles in 41½ min., 49·2 m.p.h.—brought double track, and speeding along it to 75 m.p.h. Montreal West was reached at 8.47, 19 miles in 18 min., 63·3 m.p.h. The run really ended here, the remaining suburban 4·7 miles including another stop at Westmount. Ottawa to Montreal West, therefore, with one stop and a dead slow, 106·6 miles, had been run in 111 min., 57·6 m.p.h. The terminus, Windsor, was reached at 9.01, four minutes early, the whole journey having been made in ten minutes under schedule.

The chief features of these two runs were the speed and the rough riding, which, however, had little connection, the latter detracting in no way from the credit of the fine "2800s," their good riding qualities having always impressed me under normal circum-

stances. All locomotives give plain evidence when a shopping is due, and these two were not exceptions. I have ridden on far worse-behaved engines, one or two examples having been in Britain, where the track certainly had nothing to do with it, the engines being solely responsible. The finest engine can develop defects producing rough riding, but adjustment will remedy them.

Particulars of Runs Between Ottawa and Montreal

Train No. 7 (read down).					Train No. 2 (read up).		
Time.		Speed, m.p.h.	Miles.		Time.		Speed, m.p.h.
Booked.	Actual.				Booked.	Actual.	
p.m.	p.m.				a.m.	a.m.	
Dep. 8.15	8.15	—	—	Montreal	Arr. 9.05	9.01	—
Dep. 8.21	8.22	—	2·00	Westmount	Dep. 8.57	Dep. 8.56	—
Dep. 8.27	Dep. 8.30	—	4·07	Montreal W.	Dep. 8.50	Dep. 8.47	63·3
Dep. 8.48	Arr. 8.52	51·8	23·7	Vaudreuil		Pass 8.29	49·2
	Dep. 8.53						
Dep. 9.30	Arr. 9.32	52·3	57·6	Vankleek Hill	Dep. 7.47	Dep. 7.47½	63·2
	Dep. 9.33			(flag)		Arr. 7.47	
Arr. 10.25	Arr. 10.25	61·9	111·3	Ottawa	Dep. 6.50	Dep. 6.56	

Montreal West to Ottawa, 106·6 miles, with two stops, 115 min., average speed 55·6 m.p.h., inclusive.

Ottawa to Montreal West, 106·6 mles, with one stop and a dead slow, 111 min., 57·6 m.p.h. inclusive.

A good instance of this occurs to me, concerning one of my runs on a fine British express engine, notably good riding, of a class for which I have a whole-hearted admiration. Its action on this occasion was so unexpectedly bad that much of the pleasure of the trip was banished; the trailing truck was responsible, and had been reported the day before, for attention when it got back to London. I mentioned this, quite good-naturedly, not in any way in a carping spirit, in the subsequent article which was sent to the company concerned for review prior to assuming proof form. The script came back with all reference to rough riding ruled out. This did seem to me rather exaggerated sensitiveness; why hide the fact, after all known to everyone, that the finest piece of machinery can develop defects sometimes? No locomotive is perfect—even an L.M.S. "Princess Coronation," for instance, probably has something about it that might conceivably be improved, though the simile does look rather far-fetched in black and white, and should not be taken too seriously! Myself, I cannot think of anything.* But you see what I am driving at. The same thing applies to a Canadian Pacific "2800." There is nothing derogatory in mentioning a fine engine riding roughly after tens of thousands of miles' running without shopping—they all do.

An even more striking instance relates to a class of British engine I had always liked the look of, and of which I had never heard anything but good reports. It happened that quite by chance, having missed the engine on which I should have travelled, I boarded one of this class to get to my destination. It turned out to be the very worst-behaved engine imaginable, doing everything a locomotive should not do—and some things one would never think it could do, and stay on the metals. I am not as a rule nervous in the company of locomotives—I am too fond of them to be afraid of them!—but I admit being scared on this infernal machine. Most of the run was made at high speed, 75 m.p.h. or more, and it was simply an endurance test for everyone on board. The fireman reeled and staggered about the cab, his scoop hitting the back plate almost as often as the fire-door, scattering coal over the floor. The pitching and rolling, even on straights, the convulsive wrenching on curves, the never-ceasing vibration, all combined to keep me keyed up and apprehensive. I felt any minute might see us leave the track and roll down an embankment! I am not exaggerating in the least—it was just like this. At the end of the run, sore, shaken and disgusted, thankfully stepping down on to the solid platform, I said: "Well, I'd like to tell you what I think about her, but I can't find the right words." This brought a shout of laughter from the crew, and the rejoinder: "Aye, they're the wor-r-ld's wor-r-st!" In this case the trouble was fundamental, not merely functional—mistakes in design, though exactly what, nobody seemed to know. I was told all the class were the same, and though all sorts of things had been tried to remedy their defects, little improvement had resulted. Everybody loathed them, particularly the men who had to handle them. I was asked on no account to write anything about the run, as it had never been intended that I should travel on an engine of that class, and the officials were sorry that I had. I assured them we were in complete agreement on this point, and that nothing would induce me to do so again. There is only one thing to do with an engine like that—scrap it as soon as possible.

Of course, the track can have considerable effect on an engine's action, but I do not think it had much to do with matters between Montreal and Ottawa, and seldom has in Britain. An engine that misbehaves over the average permanent way there must indeed be hard to please. On this side of the Atlantic—so far as my experiences go—the track ranges from good to very indifferent. On some branch lines I have seen permanent way little better than a contractor's temporary lay-out; only engines with spring gear equalised could operate over it, and at low speed. It would never be tolerated in the Old Country, but is allowed to serve here for the time being. Steel is as a rule no heavier than in Britain, 100 lb. being standard, though 130 lb. is used in the mountains. But whatever the weight, it does not seem to me that "inverted T" rails, spiked down, could ever be as sound a bed as bull-headed, bolted, chair-supported wedged ones. Broken rails are seldom found in England, and even when a rail does break there, the chairs and wedges hold it firm, close up to the head, whereas when a "T" rail goes there is nothing to hold it at all except the spikes, which often work up and allow the rail to cant. Now I come to think of it, Gilbertson, who piloted the "Royal Scot" on her 11,000-mile tour of Canada and the States, should be a good judge of the respective merits of British and North American permanent way. The "Royal Scot" was, I believe, sternly restricted as to her speed, but her unequalised springs must have made the engine a good indicator of track conditions over here, and I much regret forgetting to ask Gilbertson about this when I spent several hours with him at Carlisle a couple of years ago. My excuse may be that I found his reminiscences so absorbing I hated to interrupt with questions. Why was that tour so inadequately reported? It was a pity. An observer travelling with the train could have picked up so much data of interest to railway men, and valuable lessons might have been learnt.

So much for the Montreal-Ottawa fast trains. Considerable delving into time-tables lately has failed to bring to light any train in Canada timed faster over a distance of 100 miles or more, but Canada is a big country, and I may have missed something. If so, I am quite willing to sit corrected. They gave me two very interesting runs, but I thanked whatever gods there be many times that "Nos. 2826 and 2810" were fitted with deeply padded "stuffed seats."

(To be continued)

* Except perhaps "stuffed seats," grateful and comforting to persons with insufficiently-stuffed bottoms—E. H. L.

A Century of Tunnelling*

No. I

THE march of science has led both to an increase in the demand for tunnels and at the same time to improvements in tunnelling methods which have made possible their economical construction in increasing length and size, and has enabled such work to be carried out in more difficult ground. Among these advances, many of which are associated with mechanical engineering progress, may be mentioned:—

(1) Power drills and improvements in drill steel.
(2) Improvements in explosives.
(3) Mechanical methods of clearing and hauling spoil.
(4) Improved methods of lighting and ventilation.
(5) Use of electricity.
(6) Use of compressed air for tools and plant.
(7) Use of concrete as a lining material.
(8) Use of cast iron lining.
(9) Methods of pressure grouting.
(10) Use of the shield for tunnelling.
(11) Use of compressed air in tunnelling in water-bearing soil.
(12) Improvements in pumping machinery.

All these and many others have played a part in increasing the rate of construction, in reducing the cost of tunnels, and in enabling them to be built where, with the methods available a century ago, they would have been impracticable. One has only to read an account of the stupendous difficulties met with in the construction of the first Thames tunnel and contrast it with the comparative ease, certainty, and precision with which a tunnel in a similar site is constructed nowadays to realise what an advance has been made in the art. But it should not be forgotten how much is owed to the early pioneers, and that it is largely due to their

* Institution of Mechanical Engineers, November 21st. The Twenty-eighth Thomas Hawksley Lecture, by W. T. Halcrow.—Abstract.

efforts that modern practice has reached its present state of development.

Water in Tunnels.—Even in hard self-supporting ground, such as rock, water may be met with in considerable quantity from springs or fissures. These must be plugged, or if this is impossible provision must be made to drain away the water. In softer ground the percolation may be general, and in such soil as water-bearing gravel it may be very heavy. This introduces difficulties in regard to prevention of slips, as well as those connected with drainage and the construction of the lining.

A revolution in tunnelling through water-bearing strata has been effected by the introduction of the use of compressed air. This enables the internal pressure in the tunnel to be raised to a degree above atmospheric pressure, sufficient to balance the head under which the water is flowing. As long as this pressure is maintained, water will be unable to percolate into the tunnel and the work can be executed in the dry. Compressed air is the accepted remedy against water, and it can be used in any type of tunnel and not only in those where a shield is employed.

The usual practice is to build a bulkhead in the access shaft or across the tunnel at a point where the walls are either naturally impervious or have been rendered so by the lining, and to introduce compressed air on

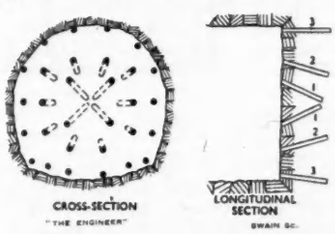


FIG. 1—*Method of Drilling Tunnel in Rock*

the working side until the pressure is raised to the requisite degree. Through the bulkhead an air lock is constructed for the passage of men and materials.

The use of compressed air complicates the process of tunnelling in that the spoil, materials, and men must all pass through the air lock. Excepting occasionally in tunnels of small size, it is usual to provide separate air locks for men and materials. In the use of compressed air, two limitations arise. The first is the maximum pressure under which the men can work. This is generally put at 35–40 lb. per square inch above atmospheric pressure, corresponding to some 80–90ft. static head of water. The second is the difficulty, in material such as open water-bearing gravel, to maintain the pressure, on account of the great loss of air by leakage. The tendency to air leakage arises from the difference of hydrostatic pressure between the top and bottom of the tunnel. If the air pressure is sufficient to hold back the water at the bottom, then it will be in excess at the top of the tunnel, and under this excess of pressure the air will tend to escape.

Tunnels in Rock and Self-supporting Ground

These tunnels generally require neither temporary timbering nor permanent lining, and the problem resolves itself into one of devising the most economical and expeditious means of excavating the material and removing it. Subsidiary problems comprise the drainage of any seepage water and the provision of adequate ventilation. The difficulties naturally increase to some extent with the length, size, and depth of the tunnel; but with the mechanical appliances now available, no serious limitations are imposed, and tunnels of large cross section and great length are frequently constructed.

The driving of a rock tunnel comprises three operations—(1) drilling, (2) blasting, and (3) removal of spoil—and it is the third of these which now mainly governs the rate of progress. A hundred years ago the holes were hand drilled with hammer and bar, and after blasting the spoil was hand loaded into wagons and hauled by man or animal power. The old method of hand drilling may be said to be now entirely superseded by power drilling in tunnels of any appreciable length. The rate of driving that can be effected with power drills is in advance of hand clearing (for which in its turn mechanical devices have been adopted), and it is on the efficiency of these operations that the rate of progress of the tunnel now principally depends. Mechanical plant for clearing the spoil entails a certain minimum cross section of tunnel, and it is sometimes found expedient to increase the area above that required for its actual purpose, so that suitable plant may be installed and the speed of driving be increased thereby.

Excavation.—The minimum size to which a heading can be conveniently driven is about 5ft. by 6ft. If the section is not greatly in excess of this, then the tunnel can be driven to its full size at once. Where it is considerably larger, the usual practice is to drive a heading in advance of the main tunnel, following this up by widening it out to the full section. This heading may be placed centrally, or at the top or at the bottom of the section. American practice, which is extensive as regards long tunnels in rock, generally favours a top heading with a bench, the length of which may be 1½ to 2 times the width of the tunnel. The heading and bench are drilled simultaneously, and are usually blasted consecutively, the heading before the bench. The bench is then cleared to enable drilling to be resumed, and while this is in progress, the main spoil is cleared and evacuated through the nearest adit or shaft. Recently there has been a trend towards excavating the tunnel to its full section at once, without driving a preliminary heading. The operations of excavating and clearing are carried out alternately. This method was employed on the tunnels of the Colorado river aqueduct and the Delaware water supply scheme, which were 18ft. and 19½ft. in diameter respectively.

In drilling the heading, the holes are placed at an angle to the face, the object being to cut out a central wedge which the rim or outer holes will enlarge to the full size of the heading. For this purpose the centre holes are generally fired ahead of the rim holes, or, alternatively, a somewhat heavier charge is placed in the rim holes or a stronger explosive is used in the bottom of them. In modern practice, the firing is done electrically.

One hole per 3 square feet of face in igneous rock and one hole per 5 square feet in sedimentary rock is the average number required. The cut will generally be about 80–90 per cent. of the depth of the hole (measured square to the face) for short holes and rather less in the case of longer holes, but to attain rapid progress in driving, fairly long holes are necessary. Fig. 1 shows a typical arrangement for a heading.

It is usual to make the holes at least

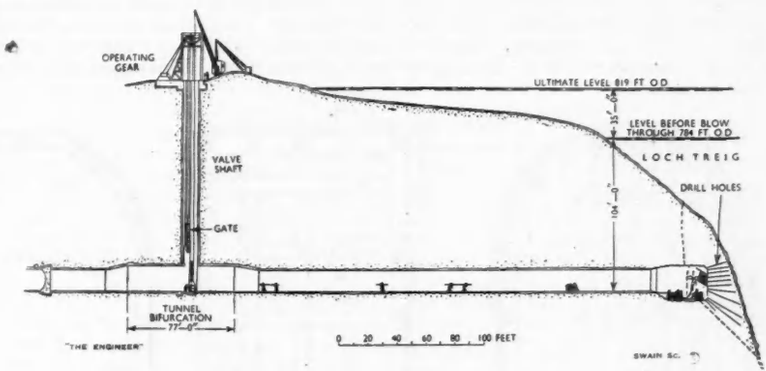


FIG. 2—*Diagram of Heading and Drilling at Ben Nevis Tunnel Intake*

6–8ft. long, but in some recent tunnels 14–15ft., and even 20ft., has been adopted. A limit is, however, set by other considerations, and very long holes are not economical. They involve heavier charges of explosives, a larger amount of spoil to be cleared after each blast, and a larger proportion of holes which may require recharging, with consequent delay. It is important also to adopt a length of hole which is convenient in relation to the shift. To ensure rapid progress and economical work, the shifts must be

FIG. 3—*Ben Nevis Tunnel, Rock Face 25ft. in diameter Drilled for Underwater Blast*

arranged and the operations timed so as to effect a smooth and continuous sequence. The cycle of operations naturally varies with the conditions. A typical example is as follows:—

	Hours.
Blasting heading and bench	2
Clearing heading...	2
Setting up columns for drills	2
Drilling and clearing	6
Total	12

The complete cycle is here 12 hours, allowing for a two-shift day. Conditions in some cases might favour a shorter length of hole and a three-shift day.

Explosives.—A hundred years ago black

powder was the only explosive used. It is now entirely superseded by gelignite or similar high explosive. That most commonly used is 60 per cent. low-freezing gelatine and occasionally stronger up to 80–100 per cent. Apart from its being a more powerful explosive, it has the advantage over powder that it breaks up the rock into smaller pieces, which can be more readily handled. Liquid air (or liquid oxygen) has been employed as an explosive and has the great advantage of the elimination of blasting fumes. This is, however, discounted by disadvantages, particularly those arising from its volatile nature; in a large face the charges placed first lose a large part of their power before the whole round is placed ready for firing. Liquid air is now generally used in surface work only.

Shape of Tunnel.—The shape of the tunnel is governed to a large extent by the purpose for which it is required, but some modification may be desirable to facilitate construction. In tunnels for water a circular shape gives the best hydraulic section, but it is a more expensive and difficult shape to excavate and, further, it involves a "backfill" or other support for the track. It is usual, therefore, to adopt a flatter invert, and to compensate for the reduced hydraulic efficiency by a slight increase of size. A section commonly adopted is the horseshoe, which combines maximum width and headroom with a flat invert.

Headings and Adits.—In driving a long tunnel the total rate of progress naturally depends on the number of working faces. A short tunnel would be driven from the two ends only; but in driving longer tunnels intermediate shafts are sunk or adits driven, each of which provides two more working faces. Adits have the advantage over shafts in that they can be driven more quickly and the tunnel spoil can be removed through them without lift. The choice as between adits and shafts, however, depends mainly upon the topography of the country. it is sometimes expedient to take a less direct route for a tunnel at the expense of increasing its length, if this will enable adits or shafts to be put in.

Each additional adit or shaft means extra drilling, excavation and clearing plant, and in the case of the shaft of extra elevating plant also. The determination resolves itself, therefore, into a question of capital cost against speed of driving, and the ultimate deciding factor is the time available for executing the work. It is not considered advisable, however, to exceed a length of 1–1½ miles drive from a single face if this can be avoided.

Rate of Progress.—An average rate of progress in rock tunnelling ranges from 4ft. to 8ft. per cut and from 25ft. to 100ft. drive per working face per week, according to the conditions, though these rates have in cases been much exceeded. If water is met with or timbering has to be used, the rate is slowed down. The maximum weekly rate may be considerably in excess of the average, and on seven long American tunnels the maximum rate ranged from 113ft. to 184ft. per week.

In the 15ft. diameter Florence Lake tunnel, California, which was driven in 1920 through granite and had a length of 13 miles, the end faces were supplemented by two adits, giving six working faces. Eighteen-foot holes were drilled, to effect a large cut. The average progress at each face was 125ft. a week, so the total progress was 750ft. a week, or nearly 7 miles a year. In this tunnel speed of construction was the primary consideration and the cost was high.

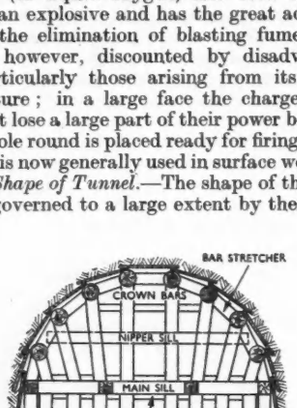
The record speed for rock tunnelling was made in the Deep Mine drainage tunnel, Cripple Creek, Colorado, a tunnel 9ft. by 8ft. and 6 miles in length. This tunnel, completed in 1939, was in granite and was driven from a single face. A remarkable rate of progress was achieved; the average drive was 49·5ft. per day, with a maximum of 61ft. The average rate was thus about 340ft. a week. The maximum recorded progress in any month was 1534ft. These figures indicate a rate far in advance of anything previously attained.

Among recent British tunnels, the 15-mile tunnel of the Lochaber power scheme, completed in 1930, was driven through igneous and metamorphic rocks, principally mica schist, from twenty-two working faces, and the maximum weekly rate of advance at any face was 91ft. The 5-mile Garry tunnel of the Grampian power scheme, driven from two faces, showed an average progress per face of 121ft. a week and a maximum of 147ft. The Seilich tunnel, on the same scheme, 4½ miles in length, was also driven from two faces and showed an average of 112ft. and a maximum of 141ft. per week per face. The two latter were, however, much smaller tunnels.

As some indication of the improvement in speed arising from the use of power drills, it may be remarked that the Mont Cenis tunnel was commenced with hand drilling, the only method available at the time. Power drills were then devised and applied, and the rate of advance was immediately increased 2¼ times, even with the somewhat primitive drills used; after a little practice, the rate increased further to 2·85 times that obtained with hand drilling.

In Table I is shown the comparative rate of advance per face per week for a number of tunnels in rock. A comparison is difficult between different tunnels, as the conditions may vary so widely; but a steady increase of speed is indicated. The most rapid improvement followed, of course, the adoption of power drilling. The average rate for a number of European tunnels, with hand drilling and black powder is shown, as quoted by Drinker.† A similar average for American tunnels shows a higher rate, but a number of more recent tunnels are included, where high explosive was used.

Tunnel Lining.—In hard solid rock lining is generally not required for the purpose of support, though occasional lengths may be met with where the rock is softer or friable and requires protection. The purpose of the tunnel may, however, render lining necessary or desirable. In some cases a smooth surface is essential. In a tunnel through rock for the passage of water a lining of concrete finished to a reasonably smooth surface reduces the frictional resistance to a notable degree and thus increases the discharge capacity of the



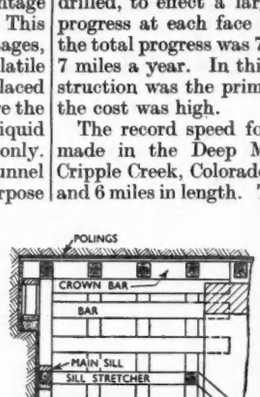
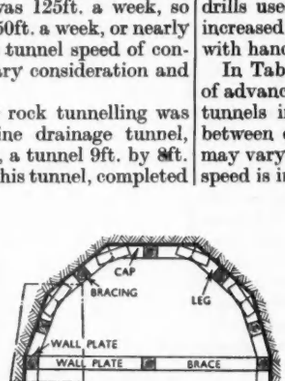


FIG. 4—*English Method of Timbering*



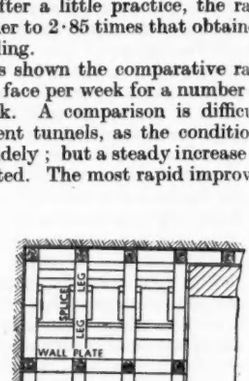


FIG. 5—*American Method of Timbering*

TABLE I.—*Weekly Rate of Advance for Tunnels in Rock*

Tunnel.	Date of completion.	Length, miles.	Approximate area, sq. feet.	No. of working faces.	Average progress per face per week, feet.
Hand drilling—					
Average of a number of European double-track railway tunnels, driven with hand drilling and black powder	—	—	530	—	6·5–12·5
Average of a number of American tunnels	—	—	—	—	9–16
Mont Cenis	1870	8	530	2	12
Power drilling—					
Mont Cenis	1870	8	530	2	32
Hoosac, U.S.A.	1873	4·6	259	4	16–30
Simplon	1906	12·5	250	2	96
Shandaken, N.Y.	1922	18	110	12	91
Florence Lake, California	1925	13	211	6	125
Lochaber (Ben Nevis)	1930	15	170–190	22	91 (maximum)
Hetch Hetchy, California (rock section)	1934	6	168	6	75–100
Garry (Grampian), Scotland	1937	5	62	2	121
Seilich (Grampian), Scotland	1939	4·5	62	2	112
Haweswater, Yorkshire	1933	4·9	81	2	127 (234 maximum)
Yewbarrow, Yorkshire	1931	0·8	81	2	127 (220 maximum)
Colorado River Aqueduct:					
Seven tunnels	1938	23	250	—	118–173 dry
Five tunnels	1938	45	250	—	41–150 wet
Delaware water supply	1940	—	270	—	120 hard rock, 250 shale
Cripple Creek, Colorado	1939	6	72	1	340

† Drinker, H. S., 1878, "Tunnelling, Explosive Compounds, and Rock Drills" (New York).

tunnel, or alternatively, reduces the size of tunnel required for a given discharge.

In tunnels where not only a smooth finish but absolute water-tightness is essential, as in certain subway tunnels and in magazines, a satisfactory method is to make a separate inner lining and to allow any percolation through the walls of the tunnel to drain away through the space between the inner and outer linings.

For rock tunnels requiring a smooth finish a cement gun can be effectively and economically employed to render the sides and arch, if the overbreak is not great.

[The lecturer then described a number of notable rock tunnels; we excerpt only the following reference to the Lochaber (Ben Nevis) tunnel.]

An interesting feature of this tunnel was its inlet into Loch Treig at a point 104ft. below water level (Fig. 2), where the rock consisted of sound mica schist. The tunnel was driven to within 85ft. of the lake; the heading was then kept 20ft. in advance and taken to within 16ft. of the water. The tunnel was next widened out to its full section at this point, the sides, however, being left at a distance of 20ft. from the water. A strong concrete bulkhead was built across the tunnel just in front (*i.e.*, downstream) of the inlet sluice shaft. In the thin rock wall left against the lake (Fig. 3) 135 holes were drilled to within 2ft. of the water. These holes were loaded with a charge of 3435 lb. of gelignite and fired. Part of the *débris* fell into a sump specially prepared for that purpose and the remainder was cleared with a dragline scraper. The inlet gate was then lowered and the bulkhead removed.

A somewhat similar lake junction was carried out in 1940 at the Snow Lake tunnel in America. This tunnel, 5ft. by 7ft. and 2350ft. long, had its inlet in Snow Lake, 165ft. below water level. The methods adopted were much the same as at Lochaber; but after careful testing a thinner rock wall was left to the final blast, which was effected with thirty-two holes, 4½–5ft. long, the charge being 220 lb. A rather larger sump in proportion to the material in the wall was made to accommodate the *débris*, and little or no subsequent clearing was found necessary.

Tunnels in Soft Soil and Soil which is Not Self-supporting

This class covers tunnels in material which is not self-supporting; it excludes those constructed with the aid of a shield. Timbering is required to prevent the roof or sides from caving in during construction, and it is ultimately replaced by a permanent lining. Though the material is in itself easier to excavate than rock, the difficulties are otherwise much enhanced. In addition to the removal of spoil from the tunnel, materials for lining and timbering have to be brought in, thus introducing two-way loaded traffic. Further, the timbering takes time to erect and restricts the working space. In extreme cases, as in mud or running sand, the face has also to be supported. In the Hudson River tunnel an attempt was made to harden the mud at the face by heat. In other cases chemical consolidation of the ground and grouting have been adopted.

The main feature of this type of tunnel is the timbering required to support the sides and roof until the permanent lining is built; where, owing to the nature of the soil, the timbering is heavy, it forms the operation which largely determines the rate of progress that can be maintained. In these days, if the ground is so bad as to necessitate very heavy timbering, a shield would generally be used.

There are two main systems of timbering, which differ so greatly that I may refer briefly to them.

The English system comprises a series of longitudinal bars supporting poling boards along the roof and sides, and separated by cross pieces or stretchers. These bars are in turn supported by props resting on sills, the number of sills being determined by the height of the tunnel. The arrangement is shown in Fig. 4.

The usual procedure is to start with a top heading and get in the two top or crown bars first. The heading is then widened on each side to get in further bars. These bars are propped on an intermediate or "nipper" sill. The top section being completed, excavation then proceeds downwards, and the support is transferred to the main sill, and thence to the middle and bottom sills. Soft ground necessitates a heavy mass of timbering which leaves little working space. The bars are now often replaced by steel beams which take less room.

The American system comprises the support of the roof by a series of arches at right angles to the axis of the tunnel. These rest on wall plates, propped on intermediate and bottom sills. The wall plate and bottom sills on each side of the tunnel are strutted by a brace. The arrangement is shown in Fig. 5.

Any considerable length of tunnel under timber is to be avoided, not only for reasons of safety, but also to reduce the amount of timbering required. The lining is therefore put in as rapidly as possible. Notwithstanding this, the consumption of timber is very large. Drinker gives the quantity of timber required per 100 cubic feet of excavation as from an average of 7 cubic feet for firm ground to an average of 53 cubic feet in running sand.

A recent development is the use of pressed steel liner sheets, supported by steel ribs and struts, in place of timbering. The liner is light and easily erected and the system saves excavation and gives more working room. If compressed air is being used in water-bearing soil, steel sheets, as they involve fewer joints, lead to less air leakage. The steel liner is generally left in when the concrete lining is placed, and in work where any settlement would be serious (as under streets) the space, if any, behind the liner is grouted.

In excavating tunnels in soft materials the work is generally done by hand, the working space being too restricted for the use of mechanical excavators. The ordinary hand tools, such as picks, spades and in clay, cutting knives, are often supplemented by pneumatic picks and spades and power knives.

This class of tunnel is most generally lined with brick or concrete, deposited *in situ*. Various methods are used for transporting the concrete from the mixer to the work, a convenient device being a conveyor belt. An interesting innovation which has recently been successfully employed consists of pumping the concrete through a steel pipe line from the mixing station, outside or further back in the tunnel, to the work. In long tunnels steel shuttering is frequently used and is sometimes fixed on travelling carriages.

(To be continued)

Sixty Years Ago

The Combination of Manufacturers

The combination of labour in trades unions was powerful and effective in this country sixty years ago. The corresponding combination of employers in protective associations had still a long way to go before it reached the highly organised state which it now has. In our issue of November 25th, 1881, a leading article was devoted to a discussion of the combination of manufacturers. We sought to show that of the two methods of conducting trade, the "republican" or co-operative, and the "monarchical" or individual management systems, the republican had been repeatedly tried and had almost always ended in failure. The co-operative cotton companies of Oldham provided the only instance in which it was possible to say that the republican system had succeeded, and even in that instance some of the mills had succumbed, while the management of the successful mills had really rested in the hands of a very few well-selected leaders. As an example of the failure of the republican system we mentioned the case of the Ouseburn Co-operative Engine Works, which ended in a few years in hopeless and unmitigated failure, in spite of enjoying a command of borrowed capital such as few private firms possessed. We held it to be a firmly established fact that the master who found the capital should manage the business, and as a corollary that if the monarchical system was to prevail it was necessary to ensure that the master received an adequate return on his invested capital. In their struggle with labour, however, the masters were at a disadvantage in that they were not organised to protect their interests to the same high degree as were the workpeople. On many occasions the masters had united in associations, but generally only to meet some immediate emergency, and frequently they had had to give way because some member of the association had found it impossible to remain loyal to it. The end of the great Nine Hours Strike in the engineering industry illustrated that point. The northern masters had failed to hold their own because a single firm in Sunderland was unable to face the consequences of a further suspension of business. It yielded and the breach in the employers' ranks quickly spread to Newcastle and then throughout the whole of the North of England. News had just reached us that the National Federation of Associated Employers of Labour had ceased to exist. It had been started in 1873 during the heat of a wages conflict, but with the passing of the dispute it languished and would have become defunct sooner than it did but for the fact that it was kept artificially alive to watch the progress of the Employers' Liability Bill. With the passing of that Bill it had been allowed to perish. Its history, we thought, was one more illustration of the truth that it was only in the presence of some extraordinary circumstances that employers could be induced to associate themselves together for mutual effort. We urged the masters to regard the unfavourable results of former combinations not as warnings that all combination would be unsuccessful, but as lessons teaching how it might be made to succeed.

The Care of Batteries.—Efforts are being made by the Edison Swan Electric Company, Ltd., to encourage motorists to make regular use of the siphon hydrometer as a measure against sudden battery failure, which has become so common in these days of short and infrequent runs. If, the company states, instead of waiting for the usual signs of battery deterioration the motorist would make a regular practice of taking specific gravity readings of the electrolyte in his battery, he would be made aware, well in advance, that his battery needed an independent charge. The siphon hydrometer is very easy to use. It resembles a large pipette and is inserted into the cell and filled with electrolyte. A reading is then given on the specific gravity scale which is placed in the pipette beforehand. This little scale floats in the extracted electrolyte like a fishing line float and an accurate reading is easy to take. If the specimen of the electrolyte gives a reading thirty points below the manufacturer's specified specific gravity or below the specific gravity at which the battery is known to be fully charged, the battery needs an independent charge. The company has available for sale an improved type of siphon hydrometer. It informs us that it is less anxious to sell these hydrometers than to maintain the supply of batterise for war work without victimising, more than can be helped, the private motorist and contractor.

Sorocold's Waterworks at Leeds, 1694*

By F. WILLIAMSON, F.R. Hist. S., and W. B. CRUMP, M.A.

(*Continued from page 352, November 21st*)

So far there is no reference whatever to the third component of the waterworks—the cistern or tank up to which the water was pumped by the water engine, for distribution thence through the mains into the houses. There is, however, a passage in the "Topography,"[11] which completes the picture, though the cistern is mentioned rather incidentally, by way of parenthesis, in the discussion of another matter.

Leaving St. John's Church, Ralph Thoresby notes Harrison's Almshouses adjacent to it, and then continues :—

"The Street adjoining to the Bar is yet called Lid-gate. . . . This being the highest Part of the Town was made choice of for building a Tower upon. I have perused some Manuscripts . . . wherein it is called the Tower-hill; and as a farther Confirmation hereof, Anno 1695, when certain Workmen were digging deep to lay a secure Foundation for the vast Cistern, which was to serve as a Repository for the River Water (which was then first conveyed in Lead-Pipes from the Bridge Foot to this Place) at a considerable Depth below the Foundation of the late Houses, they found prodigious large Stones and the Ruins of a great Wall. . . ."

Although Thoresby had discursively filled ten pages since he defined the position of Red Hall as "near the West-Bar, at the Upper Head-Row," he still appears to refer to it when he turns northwards into Lidgate. This may be regarded as the length of road common to Woodhouse Lane (his "ancient road from the North") and Wade Lane. His elusive Tower Hill may be placed on the rising ground towards St. John's Church, partly occupied by the almshouses, with a frontage into Wade Lane. The site of the cistern was therefore in their vicinity—and for the moment that will suffice.

The highest part of the town was chosen as the site of the cistern, and this was essential. It was also well chosen, for an economic and simple distribution, for it was near the head of the main street of the town, as the engine was near the foot of it, at the bridge. The elevation between the two was perhaps the most important point in professional eyes, for it was the chief test of the efficiency and power of Sorocold's pumps. Thoresby does not overlook the point, though his statement about the elevation in the text (page 80) is corrected in the Appendix (page 576) to read, "The Elevation of the Water is 147 Feet."

How soon this feature attracted attention may be gathered from a letter addressed to Thoresby by one of his correspondents, Dr. Jabez Cay, of Newcastle. He was evidently wondering whether Sorocold's "engine" might not be a great advance on the devices then used for pumping water out of coal pits. As, indeed, it was.

"Newcastle, Nov. 6, 1694.

"I would beg one favour of you. I hear there is a man come to Leeds with a design to furnish the town with water, after a manner somewhat Extraordinary; they say he forceth the water almost half a mile upon an ascent (the ascent being about four yards perpendicular in twenty) from the river to his conservatory [reservoir]. Now I would gladly be informed of the truth of this: and what sort of an engine it is by which he does all this, that I may know whether it be applicable to our coal-works or no? and what the true height is, to which he raiseth his water? and whether his encouragement from the town be like to answer the expense of so great a work?"[12]

It may be said at once that Thoresby's estimate or calculation of the height the water was pumped from the river to the cistern was nearly double the true value. Meanwhile, another important contribution of Thoresby to a knowledge of Sorocold's installation demands attention, for it provides a complete lay-out of the mains in the town. Some years ago the Thoresby Society published a further selection of letters received by Thoresby, and the editor carefully recorded some notes made on the back of one of them, dated January 31st, 1694/5. They were measurements made by Thoresby, though the object in view was not then apparent. It is now clear enough that they provide a complete survey of Sorocold's pipe lines through the streets of Leeds.[13]

Measures of Leedes Streets.

From the Mill to Bore [Boar] lane	240 yds.
From Bore Lane to Kirkgate	160 dit.
Kirkgate to Upperhead row	220 dit.
Upperhead row	140 dit.
From Bar to the cistern	105 dit.
From Church to Cawl [Call] Lane	260 dit.
Cow [Call] lane to Briggate	230 dit.
Call lane	365 dit.
Nether headrow	160 dit.
New Street	087 dit.
Bore Lane	300 dit.
Part of Mil hill	094 dit.

The first five are of the main delivery pipe from the engine-house at Pitfall Mill to the cistern, the first three covering the length of Briggate. The total length is nearly half a mile. Side by side with this main would be the chief distributing pipe. The remaining measurements indicate the continuation of it, or branches from it. The first two were laid along Kirkgate and the next along Call Lane from Briggate to Kirkgate. Three hundred yards would cover the length of Boar Lane to the West Bar at the end, and a short branch off this served the first part of Lower Mill Hill. At the top of Briggate the pipe was continued along the short New Street (now Upper Briggate) which ended at the steps and gate of St. John's Church.

Thoresby's interest in the lead pipes—which he mentions so frequently—provides one more fact of value. He put samples of them, given him by George Sorocold, into his museum, and notes them in the catalogue of its contents: "Rings of the different Sizes of the Lead Pipes, by which the River Water is conveyed through the several Streets at Leedes, one of which is a Foot in Circumference."[14] It seems probable that the last was the largest pipe, used to deliver into the cistern. A circumference of 12in. is equivalent to a diameter somewhat less than 4in., and consequently the bore would scarcely exceed 3in.

The measurements given in Thoresby's list appear correct and call for no comment, with the exception of the one along Upperhead Row—140 yards. This is not the whole length as far as the site of "West Bar" (more often called Burley Bar)—which amounts to 230 yards—but only as far as Red Hall, or King Charles Street, facing the wide opening into Woodhouse Lane and Wade Lane. This is, in fact, the exact point where the main water pipe should turn to pass up Lidgate to the cistern. The next measurement gives the distance—105 yards; but it is described as "From Bar to the cistern." The reference to a "bar" recalls Thoresby's sentence quoted earlier, "The Street adjoining to the Bar is yet called Lidgate."

PART OF MAP OF LEEDS IN 1815

Where and what was this Bar, to which Thoresby gives no name? Its distance from the cistern (only 105 yards) again seems to rule out Burley Bar and place it not vaguely "near" but within a few yards of the Red Hall. Yet Thoresby gives no hint of any other bar than West Bar hereabouts, so possibly he is only using the name loosely for any spot in the neighbourhood of the bar. But there is another possible explanation. John Cossins produced "A New and Exact Plan of Leedes" about 1725 (the year of Thoresby's death). It is more decorative than exact, and "Burley Barr" is shown even further away from Red Hall, at the top of Mill Hill Lane (now Basinghall Street). At the entrance to the road that goes past the almshouses there is also drawn a gate; indeed a double gate hung from stone pillars.[15] It is not named, and it may be an imaginative rendering of the Lidgate itself—the swing gate hung on the border of the arable lands of the village to exclude cattle. So it is just possible that this Lidgate is what Thoresby called the Bar, and from it he measured the distance to the cistern. In position it agrees with his measurements.

The "Water Engine" near the bridge is shown on every plan of Leeds during the eighteenth century, but none of them is on a scale large enough to mark the cistern. The first that does is a beautiful and accurate map pub-

* Reprinted from the Thoresby Society's "Miscellanea," 1941. Abstract.

lished in 1815 from a survey made by Netlam and Francis Giles. As before that date the water supply of the town had been improved by a body of commissioners appointed by Act of Parliament, it will be well to inquire what changes were authorised and what had been effected, before turning to the plan to see what information it supplies.

The Act in question[16] (30 Geo. III, c. 68), "for better supplying the town and neighbourhood of Leeds with water," gave the "Commissioners of the Leeds Water-Works," appointed in 1790, the power to purchase the existing waterworks and to extend or improve them. But evidently no radical departure from the system established by Sorocold was contemplated. So the Act throws some light, though not so much as could be desired, on the management of Sorocold's waterworks after they had been in use for a century.

The Commissioners were given the power to purchase the remainder of a lease for a long term of years of Pitfall Mill, "with the works, rights, privileges, and other appurtenances." The purchase price was fixed at such a sum as would produce, when invested in 4 per cent. Consolidated Bank Annuities, an annual income of £150, "being the amount of their present Rent." In other words, the Commissioners were to buy £3750 Annuities, and to distribute them among the "several persons" who were the proprietors, according to their individual interests in the works. The owner of Pitfall Mill was named and a lessee of another part of it, but the proprietors of the waterworks remain undisclosed. What is evident is that they received a fixed rent of £150 from some other unknown person or persons who "farmed" the waterworks and managed them.

As the Commissioners might not erect a "fire-engine" above "Bondman's Dam" at the King's Mills, about a furlong above the bridge, it seems likely that they proposed to replace Sorocold's water wheel by a steam engine. They thought it advisable to go that distance upstream for their new intake in order to draw water from the river above the cluster of old watermills in the town. They little dreamt that within a couple of years Benjamin Gott would install a Boulton and Watt steam engine in a great new mill a mile higher up and plant his dye-house on the banks of the river.

With the dawn of the nineteenth century, the growing contamination of the river water was obvious, and is commented upon in an early description of the new works. The supply was, it says, "brought by a tunnel from the King's-Mills to the Water-Works near the Bridge, from which place it is forced by a powerful Engine into three very large reservoirs, situated at the highest part of the town, and from which, after remaining a certain time to deposit its impurities, it is distributed by leaden pipes, into every part of the town, and almost into every house. . . . It is much to be lamented that the water could not be taken from the river above the numerous Dye-Houses erected upon it."[17]

However, the point of immediate interest in this description is the provision of increased storage. These three reservoirs are shown on the Town Plan of 1815, and were not equal in size. The smallest was within the quadrangle of the Harrison Almshouses; the second, about twice the area, was near the gate of St. John's Church; the third, about four times the size, was in Albion Street, just above the present insurance building at the corner of Commercial Street (see Fig. 2).

The first, some 30ft. square, is clearly from its position the vast cistern that Thoresby watched under construction in 1694 on Tower Hill. It was remiss for so distinguished a topographer to be so vague in his topography, when the site of the cistern could have been so easily defined. By 1815 the site had undergone a most curious change, for a block of twelve new almshouses, "forming a square within the old quadrangular court," then surrounded the cistern. They were erected by the Harrison trustees under the terms of the will of Alderman Iken, dated 1795.[18] A narrow passage on the north and south axis gave access to it; otherwise the cistern was enclosed and invisible. Probably the cistern was abolished about 1840, when a new waterworks company launched the nucleus of the modern system.[19]

The Plan of Leeds in 1815 possesses a feature as helpful as it is unexpected, for the surveyors determined the relative altitudes of points in the town. They had to choose their own datum or zero point, and this was their system:—

> "The Figures in the Streets denote the Elevation of those Places in Feet and Inches above the Waste Wear of the Water Works Engine on the East side of the Bridge."

Nothing could be more convenient for the purpose of this inquiry. Thus the bottom of Briggate at the corner of Swinegate was 11ft. above the water level. The elevation of Upper Headrow was, at Briggate, 59ft. 6in., and opposite Red Hall or Lands Lane 69ft. 6in. At the reservoir the reading was 87ft. 4in. "to Bed of Res^{r}." The heights of the other reservoirs are measured similarly. The total lift of the water from the river was therefore little more than 90ft., in place of the 147ft. stated by Thoresby. Without a little surveying it is not easy to deduce the exact height of the ground level at this point, but the Bench Marks on the Five-foot Plan of Leeds by the Ordnance Survey (1850) are 167·2ft. at the foot of the tower of St. John's Church and 93·2ft. at the northern end of the bridge. Allowing a drop of 11ft. to the water level, these give an approximate rise of 85ft. The heights obtained by Netlam and Francis Giles are reasonably in accord with the more accurate readings of the Ordnance Survey. At the Albion Street reservoir their figures suggest that it could scarcely be deeper than 6ft. or 7ft., and the older one at the almshouses was probably less than that. It might not even exceed 4ft., with a capacity of 24,000–25,000 gallons.

The only aspect of Sorocold's waterworks at Leeds that has not now been discussed as far as the evidence permits is the construction of his "engine," as it is so often called—that is, of his pumping machinery actuated by the power of a water wheel.[20]

As Pitfall Mill stood some little way from the river and the mill race or goit ran through it, the water-wheel would be under cover, and the pumps arranged either side of it. Cossins' Plan helps us to recover the setting, even though the engine is out of sight. The goit is shown all the way from the King's Mill, running parallel to Swine Gate through the Tenter ground and crossed by half a dozen little bridges, till it comes to the north end of Leeds Bridge—hump-backed and many-arched. Below the bridge two sloops are at anchor near the town's warehouse on the northern banks. The mill goit, or rather the tail goit or "wear waste," emerges from under the Pit water mill at the corner of the Calls, and continues behind the warehouse for some distance until it falls into the River Aire at Dyers Garth, just short of Alderman Cookson's riverside garden and St. Peter's Church—"black, but comely."

That was the Leeds Thoresby knew and loved. Sorocold's waterworks were a part of it, and they appear to have served Leeds (with diminishing success) until they were superseded about the same time as the old Parish Church.

References

[11] "Duc. Leod.," page 32.

[12] "Correspondence of R. Thoresby," 1832, i, 178.

[13] "Letters Addressed to R. Thoresby," edited by W. T. Lancaster (Thoresby Soc., xxi), 1912, page 38 footnote.

[14] "Duc. Leod," page 486. Thoresby's evident pride in the use of lead pipes, rather than elm trunks, may probably be traced to the fact that they were more costly.

[15] The rare map of Cossins was reproduced on a reduced scale in "Miscellanea" (Thoresby Soc.), ix, 204. A century later "Woodhouse Bar" was set almost at the same spot (see Fig. 2), but that was a turnpike bar.

[16] See "The Local Acts of Parliament for the Town and Borough of Leeds," 1822.

[17] "The Leeds Guide," 1808, pages 112–113.

[18] *Ibid.*, page 55, and Edward Baines "Directory of Co. of York, W.R.," 1822, page 27.

[19] The square of twelve houses is shown on the Ordnance 5ft. plan of Leeds of 1850, but without the reservoir. The lay-out of the present almshouses is very different, but the site of the cistern would be in the upper quadrangle, in a line with the tower of St. John's.

[20] The authors here refer to the well-known London Bridge waterworks, and write: "The installation at London Bridge was naturally much larger than at Leeds, but the mechanism was undoubtedly the same."—Ed., THE E.

Directorate of Industrial Electrical Equipment

THE Ministry of Supply announces that the Director of Industrial Electrical Equipment has set up an Area Organisation to give advice and assistance to war factories in matters arising out of damage by enemy action to industrial electrical equipment. An Electrical Adviser has been appointed in each of the defence areas and a number of electrical engineers in the area are available as his assistants in case of need. All these gentlemen serve in an honorary capacity. The Area Organisation has undertaken, on behalf of D.I.E.E., a survey of the electrical repair capacity and the stocks of electrical equipment which could be called upon in an emergency. Close collaboration is maintained with the Machine Tool Control Area and Repair Organisation, the Ministry of Aircraft Production Emergency Services Organisation and the Ministry of Works and Buildings Emergency Works Department. The services of the Electrical Advisers and their assistants are available through these organisations. The Area Electrical Advisers, their areas, addresses and telephone numbers are as follows:—Area 1, Northern: Mr. J. Clement, the British Thomson-Houston Company, Ltd., Ellison Place, Newcastle, 1, Newcastle 25040; Area 2, East and West Ridings: Mr. L. G. Bryden, Crompton-Parkinson, Ltd., 4–6, New York Road, Leeds, Leeds 30511; Area 3, North Midland: Mr. B. Gill, The Midland Dynamo Company, Ltd., 64, Belgrave Gate, Leicester, Leicester 20172; Area 4, Eastern: Mr. J. H. Enion, The Igranic Electric Company, Bedford, Bedford 2233; Area 5, London and South-Eastern: Mr. A. W. Berry, Crompton-Parkinson, Ltd., Electra House, Victoria Embankment, London, W.C.2, Temple Bar 5911; Area 6, Southern: Mr. M. G. R. Elliott, Lancashire Dynamo and Crypto, Ltd., 94, Petty France, London, S.W.1, Whitehall 7211; Area 7, South-Western: Mr. A. H. Topham, Mawdsley's Ltd., Dursley, Glos., Dursley 186; Area 8, Wales: Mr. H. Coope, Metropolitan-Vickers Electrical Company, Ltd., Mervyn House, Frederick Street, Cardiff, Cardiff 4712; Area 9, Midland: Mr. T. G. Travis, The General Electric Company, Ltd., Witton, Birmingham, 6, Birmingham East 1941; Area 10, North-Western: Mr. J. I. Law-Brooks, Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, Trafford Park, 2431; Area 11, Scotland: Mr. G. S. Helme, Lancashire Dynamo and Crypto, Ltd., 80, Blythswood Street, Glasgow, Central 3983; Area 12, Electrical Adviser to Northern Ireland, Ministry of Commerce: Mr. H. W. Richardson, District Admiralty Electrical Engineer, Harland and Wolff, Ltd., Queen's Island, Belfast, Belfast 57223.

THE LATE MR. S. C. LLOYD.—It is with deep regret that we have to record the death of Mr. S. C. Lloyd, chief engineer and sales manager of the industrial control department of the Metropolitan-Vickers Electrical Company, Ltd. Mr. Lloyd died on November 18th, after a short but severe illness. He joined the company in January, 1919, as chief engineer and subsequently also became sales manager. His previous career included periods of service with Ferranti, Ltd., Dick, Kerr and Co., Ltd., and Crompton and Co., Ltd. He was an associate member of the Institution of Electrical Engineers.

AUXILIARY WATER SUPPLIES FOR FIRE FIGHTING.—In order to cope with the menace of the incendiary bomb many municipalities have installed auxiliary water supply systems consisting of overland pipes from convenient local sources to feed supply tanks at strategic points. The pipes have hitherto mainly been of steel, but latterly asbestos cement pipes have been favoured by some authorities. This piping is tough, light, easily transported, and laid, and resistant to corrosion and incrustation. At one well-known watering-place use has been made of the sea water, and asbestos cement pipes have been laid from the shore up the face of the cliff. The water is pumped up into storage tanks, from which it is conveyed by a double line of pipes to static water tanks in other parts of the town. In all, many miles of 9in. asbestos cement piping are employed.

The Engineer

NOVEMBER 28, 1941

VOL. CLXXII No. 4481

Contents

THE ENGINEER, November 28th, 1941. PAGE

A SEVEN-DAY JOURNAL ... 365

LEADING ARTICLES—
TRANSPORT ON THE EASTERN FRONT ... 374
OUTPUT OF LABOUR ... 375

SPECIAL ARTICLES—
CENTURY OF TUNNELLING. No. I. (Illus.) ... 368
FURTHER CANADIAN LOCOMOTIVE EXPERIENCES. No. IX. (Illus.) ... 366
RAINBOW BRIDGE, NIAGARA FALLS. No. II. (Illus.) 377

CONTACT OF COLLIDING SURFACES. (Illus.) ... 380
DIRECTORATE OF INDUSTRIAL ELECTRICAL EQUIPMENT ... 373
MACHINE TOOLS FOR PRODUCTION OF SMALL ARMS. (Illus.) ... 379
SOROCOLD'S WATERWORKS AT LEEDS, 1694. No. II. (Illus.) ... 372

LETTERS TO THE EDITOR—
PEACE AIMS ... 375
COMPOUND LOCOMOTIVES ... 376

NEWS AND NOTES—
FORTHCOMING ENGAGEMENTS ... 384
MARKETS, NOTES AND NEWS ... 383
NOTES AND MEMORANDA ... 384
SIXTY YEARS AGO ... 371

NOTICES TO READERS

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this paper or described in its editorial columns should not be taken as an indication that they are necessarily available for export.

With a view to the conservation of paper, readers are advised, in the interests of all concerned, to place a regular order for THE ENGINEER with their newsagent or direct with the Publisher.

*** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

*** *For Subscription rates, see page 2 of Advertisements.*

*** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *No undertaking can be given to return drawings or manuscripts: correspondents are therefore requested to keep copies.*

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both old and new address,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

Postal Address: "The Engineer," 28, Essex Street, Strand, London, W.C.2.

Telegraphic Address: "Engineer Newspaper, Estrand, London." Telephone: CENtral 6565 (10 lines).

TRANSPORT ON THE EASTERN FRONT

IN accordance with the principle of giving the Devil his due, we feel bound to express our admiration of the speed with which the Germans in their Eastern campaign have succeeded in organising the transport of supplies in the territories which they have wrested from the Russians. Repeatedly we have been told by our military writers that with each fresh advance the enemy's supply problems would become greater and greater, and that the increasing difficulty of solving them would soon bring his offensive to a halt or at least to a prolonged pause. Yet time and again the battle has been renewed with undiminished and even increased intensity after an amazingly short interval for the establishment or reorganisation of the supply and transport systems in the newly acquired back areas. The supplies, human and material, to be moved forward have been immense, the normal native means of transport by road and rail within the overrun territory have been poor or indifferent, and the Russians' "scorched earth" policy and the activities of their daring guerrilla bands have added greatly to the Germans' difficulties. Nevertheless, means have been quite obviously found to enable the pressure of battle to be maintained or resumed without the more or less prolonged periods of inactivity in the fighting line which, by all precedent, should have been required to enable the rearward services to be reorganised and extended. Our admiration for the enemy's achievement in this respect is strictly limited to the bare item of its speed. We reserve it as to the means employed. If rumour speaks truly, it may well be that instead of admiring the methods employed by the enemy we should express our disgust and hatred of the inhumanity and cruelty lying behind them.

As engineers, we are primarily interested in the railway aspects of the Germans' transport problems. The crucial fact to be taken into account in this connection is that the gauge of the German railways—together with the railways of Lithuania, Poland, Czechoslovakia, Hungary, Rumania, Jugoslavia, and Bulgaria—is 4ft. 8½in., while the standard Russian gauge—together with that of the railways of Finland, Estonia, and Latvia—is 5ft. Incidentally, it may be noted that the Italian gauge is 4ft. 9in., and the Spanish 5ft. 6in. It is evident that so far as railway transport in the overrun territories is concerned, the Germans have had a difficult problem to face. It is understood that since 1939 the gauge of the railways on the Russian side of the Polish division line has been altered to our Ally's five-foot standard. Hence, when the Germans began their Eastern campaign, they were faced with the necessity of making plans for the invasion of territories in nearly all of which the railway gauge was materially greater than their own or that of any of their Allies or coadjutors. Knowing the quality of the Russian roads and the enormous demand which would arise for liquid fuel suitable for use in road vehicles, it is impossible to believe that the Germans' plans were drawn in such a way as to make the development of the campaign dependent entirely on road transport. Soon after the Russian war started, and long before the advance had reached as far as it has now gone, it was credibly reported that the Germans were expending a gallon of liquid fuel to bring up a gallon to the front line by road. A continuation of such an expenditure—even neglecting the fact that as the depth of penetration increased the ratio would become still more extravagant—would by this time have resulted by itself in visibly slowing down the impetus of the attack. The fact that it has not slowed down seems to us clearly to imply that the Germans are employing the railways of the overrun territory as their principal means of moving supplies forward. It is exceedingly unlikely that the quantity of Russian rolling stock and locomotives which the enemy may have captured has been anything like sufficient to enable them to operate the 5ft. gauge lines on the scale which the military operations undertaken would require. Reports to the effect that the Germans have obtained trucks and engines from Spain may be dismissed with little hesitation in view of the fact that the Spanish gauge is even more different from the Russian than is the German. Nor can we lightly believe that the Germans had prepared in advance a large quantity of 5ft. rolling stock and locomotives ready for the day when they would attack Russia. The necessity for transhipment at the points where the break of gauge occurred would render such a plan highly unattractive to a General Staff counting very largely on speed for success. A strange story reaches us from Australia. The problem of broken gauges exists in that country, and is said to have given rise to an invention, the essence of which consists of arranging the wheels loosely on their axles in such a manner that by running a train over a form of ramp, the gauge of the wheels can be automatically increased or diminished with scarcely even a reduction in the speed of the train. It is said that the Australian railway authorities refused to consider the invention, and that shortly before the war started the inventor sold his plans to a German railway official for a few pounds. The principle of this invention is not novel. Further, even although we were prepared to grant it a much higher degree of practicability than we feel disposed to do, we would be unwilling to believe that it has now found application on the Eastern front. It would obviously require the building of special trucks and coaches or at least the equipment of existing stock with special wheels and axles. Further, while it might solve the truck and coach problem, it would be inapplicable to locomotives.

It may, we think, be considered certain that the Germans are solving the railway transport problem in the overrun territory by making use of their own rolling stock and that of their allies and friends, and that to that end they have undertaken the formidable task of converting the 5ft. Russian gauge to the 4ft. 8½in. standard. Many years ago the Great Western Railway changed large stretches of its line almost overnight from broad to standard gauge. The work involved very prolonged preparation, high organisation, and a large labour force. We believe it to be true that the Germans are now carrying out a similar programme under the conditions of modern warfare. It is reported that Dr. Todt, the engineer mainly responsible for Germany's *autobahnen* and for the construction of the Western Wall or Siegfried Line, is in charge of the work of road repair and railway gauge alteration on the Russian front, and that he has under him a force of 300,000 men, many of whom are Jewish and other conscripts. An abundance of forced labour can do wonders. In ancient times it raised the Pyramids of Egypt and in modern days it helped very materially to construct the Suez Canal. To-day, it would seem, it is being employed by the Germans in Russia

with a ferocity comparable with that with which it was exploited in the world's darkest ages.

The Output of Labour

THERE are parts of the 25th Report of the Select Committee on National Expenditure that make distinctly dull reading. That Report, as we mentioned in a Journal note last week, consists of the reply of the Government to the recommendations contained in the 21st Report of the Committee, which dealt with the output of labour, together with observations on other matters connected with that subject not specifically mentioned by the Committee. In effect it is a review of the attitude and actions of the Government in matters affecting the output to be expected from the factories of this country, and parts of it are dull because there is in fact a fairly complete agreement between the Government, the Committee, management and labour as to the principles by which the Government should be guided in the matter.

It is in fact not the principles upon which the Government should act, but the means adopted to put them into effect that are debatable. It is clearly desirable that all machine tools and machinery should be used as nearly as possible continuously throughout a twenty-four-hour day; that the hours of work of employees should not be excessive in relation to the work they have to do; that, to quote a recommendation of the 21st Report, men should be chosen "as charge hands and foremen for their qualities of leadership, tact and organising ability, as well as for their technical skill"; that adequate transport should be provided to carry workers between the factories and their homes, &c. Such things verge upon the obvious. It is when the Report gives information upon the methods that are being adopted to bring such principles into effect that it becomes interesting, and that the critical faculty becomes roused. Managements accustomed in times of peace to handling their own affairs cannot suffer gladly the interference of officials, not all of whom, unfortunately, are gifted with the necessary tact and experience. Nor can workpeople be blamed if they sometimes grumble at or even object to arbitrary rulings that may transfer them temporarily or permanently to some new place of work. Management and employees alike, having been urged to step up production as rapidly as possible, are likely to become scathing in their comments when through no fault of theirs they find that a factory's resources are not being fully used or hear of some muddle about contracts that has grossly interfered with production. But in wartime output has to be forced up at such a pace that there is not time to foresee all the consequences of any action. Mistakes, even serious mistakes, are bound to be made, however excellent may be the principles upon which the Government is working. In fact, as is well known, there has been, in this war, just as in the last, no lack of ammunition for the critics. Chief amongst those critics and by far the better informed has been the Select Committee, which, by drawing attention to anomalies and to errors of commission and omission, has done much to keep within reasonable bounds the muddle and inefficiency inseparable from wartime effort.

That, on the whole, mistakes have been neither very frequent nor very important was revealed by a recent statement by Mr. Churchill in the House of Commons. "Making allowance," he said, "for the increase of population, we have reached, in the twenty-sixth month of this war, and in some ways surpassed, the deployment of national effort at home, which, after all the slaughter, was not reached until the forty-eighth month of the last war." That comparison is not a very clear-cut one. For the character of war has changed, and the armaments that must be produced in our factories have altered. Yet, taking it at its face value as a somewhat vague but still reasonably fair estimate of the position, Mr. Churchill's statement indicates that the Government has been working along the right lines. For had there been anything seriously amiss, so remarkable a deployment could not have been wrought in so short a time. Yet high though our armaments output now is, it is still not high enough. Lord Beaverbrook has called for an increase of 30 to 40 per cent. this winter. The 25th Report shows that by its criticisms of and comments upon the actions of the Government the Select Committee has done much to make that further increase possible.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

PEACE AIMS

SIR,—Inflation is caused by an increase in the amount of purchasing power greater than the simultaneous increase in the amount of goods and services for which such purchasing power can be exchanged. It may arise by an increase in the amount of purchasing power or by a decrease in the amount of purchasable goods and services. Both these causes are operating at the present time, as so much of our productive capacity has necessarily to be devoted to producing goods which are not for sale, and at the same time the production of those munitions of war vastly increases the amount of distributed purchasing power.

The Government, so far, has prevented anything beyond a very mild form in inflation by increased taxation and by the drive of the savings movement, both being steps which must meet with the approval of all thinking people.

But the very fact that, under present circumstances, there is an excess of purchasing power should lead some people to suspect that under normal peacetime procedure there is a shortage of purchasing power.

It is impossible in a letter, even of the length that this is attaining, to explain in detail the method by which the Central Bank controls the volume of credit, and therefore controls the amount of purchasing power available to the public. Briefly stated, this is done by loans to the Government and by purchase of other securities. But in addition to this action by the Central Bank, the various joint stock banks all contribute to the action by investments on a large scale, and by advances to their customers. When a bank lends to a client they would naturally require the repayment, not only of the principal, but of interest, and therefore they take back from the public purse more than they contribute. The public purse can only stand this drain provided that it is supplied with fresh credit issued as a fresh debt by the same banking system, so that the indebtedness of the community to the banking system must necessarily increase with the passage of time.

If the banks are taking from the public purse more money than they contribute to it by the way of loans, then there cannot remain in that purse sufficient money to purchase all the goods that are produced, for it must be apparent that money paid back to a bank returns to the native nothingness whence it started.

Obviously if somebody has a bank loan of £1000 and has more than that sum to his credit in a current account at the same bank, and if he instructs the bank to take £1000 out of his current account to wipe out the loan account, that transaction is merely a bookkeeping entry. No money appears in any other account, but the borrower has relinquished his right to spend the £1000. Not only has he paid back the £1000, but he had also paid interest on that £1000 during the whole period of the loan, and that money vanishes in an exactly similar way to the capital.

This repayment to the bank of real money to a greater extent than the bank has supplied what might be termed "ghostly" money is one of the reasons why there is insufficient money left in the public purse to purchase all the goods which the public themselves have produced and desire to consume.

It is often stated that there must be sufficient purchasing power available as the cost of everything can be resolved ultimately into labour. Starting with raw materials dug from the earth, obviously the major expense is labour, but even there there may be royalties which, however, are still available as purchasing power in the hands of the royalty owners. There is also the question of capital charges incurred by the mining organisations which are not immediately distributed in the form of wages, salaries, dividends, &c. The raw material—say, coal and ore—then goes through the stages of pig iron, steel and finished metal article *viâ* the blast-furnace, steel works and engine shops.

It is to be noted that the wages that have been spent in mining the actual coal or making the pig iron or the steel have all been spent by the labour employed in these stages prior to the finished article, say, a pan, being available in the retail shops for purchase by the ultimate consumer. Therefore, when the finished article is on the shop counter, there is not available, arising out of its manufacture, purchasing power equal to its total cost of production, and that article could only be purchased assuming that a fresh cycle of production follows the particular one which we have considered. In that case there would be a greater amount of purchasing power available.

The existence of this latter cycle of production depends upon the willingness of the financial system to grant the necessary credit to the manufacturers to enable them to produce more goods. There is, therefore, a body in control of a throttle valve by which they can accelerate or retard the rate of production and so control the employment, happiness and well-being of all workers, the health and livelihood of all.

Many people, when considering this question, omit entirely this question of time lag, and do not see that there cannot be, arising from production of any one article, sufficient purchasing power to enable that article to be purchased. This point may perhaps be clearer if it be set out in the form of a few accounts, as attempted below.

Let us assume that there are three manufacturers, X, Y, and Z, X supplying certain material which is his finished article to Y, who carries it forward a further stage. X might be the yarn spinner, Y the cloth weaver, and Z the retail tailor. Y is assumed to have had a loan of £1000 from the bank, and that it is spent as shown in the following account :—

Y's Account

	£		£
To Bank loan	1000	By X for yarn	300
		,, Direct labour ...	400
		,, Charges spent during manufacture	100
		,, Charges to be spent later	200
	£1000		£1000

Too much attention should not be given to the relative proportions of material, direct labour and charges, as these obviously vary vastly with different products, and the actuarial accuracy of these figures is not a matter of great importance. As regards the charges, these have been divided into two items, some being spent at the same time as the direct labour, and others being held in reserve for depreciation, bank interest, debenture interest, &c.

Y has paid X £300 for materials and X uses this as shown in the following account :—

X's Account

	£		£
To Y	300	By Bank loan account	270
		,, Bank interest, say	10
		,, Profit	20
	£300		£300

Firm Y is assumed to have paid out in direct labour £400 and in charges during manufacture the sum of £100. His employees, and this is deemed to cover everybody from the management down, are assumed to have used their remuneration as follows :—

Employees' Account

	£		£
To Wages and salaries arising from direct labour	400	By Retailers for living expenses	375
,, Wages and salaries arising from charges... ...	100	,, Insurance, &c. ...	50
		,, Savings...	75
	£500		£500

It is assumed that their living expenses of all kinds amount to £375 out of a total of £500, and that they have spent £50 on insurance or expenses of that nature, and that their savings amount to £75. The insurances will be paid to a company and will no longer be available for immediate spending by the employees. If the savings of £75 be paid into the bank, they are still under the control of the owner, and are therefore available for immediate use.

The retailers having received £375 cannot regard all that money as being available for their immediate spending on their own personal living expenses. They have either to repay the loan of, say, £335 to the bank, or they have to keep that money for their own capital account in order that they may initiate a further cycle of purchases and sales. Their position is thus shown by the following account :—

Retailer's Account

	£		£
To Sales	375	By Bank loan account	335
		,, Profit for retailer's own living expenses	40
	£375		£375

It might, of course, be possible to go into these accounts in very much greater detail, but the above is detailed sufficiently for the present purpose.

If we now consider the banking system—not necessarily the same bank—the position would be as follows :—

Bankers' Account

	£		£
To Repayment by X	270	By Loan to Y	1000
,, Insurance, &c., by employees ...	50		
,, Repayment by retailers	335		
,, Loan outstanding	345		
	£1000		£1000

They have received from firm X £270, from the insurnace companies £50, and from the retailers £335, giving a total of £655 against their loan to Y of £1000. There is still therefore outstanding only a sum of £345, and this is the whole amount of purchasing power arising out of the work done by X, which at the stage of completion by X is available to buy the goods. Y's total cost is as follows :—

	£
Detailed cost as above	1000
Interest, say, 5 per cent. for six months...	25
Profit, say, 10 per cent.	100
Total	£1125

This, then, is the total price which Y would expect from Z who carries the work a stage further. But the point to notice is that the outstanding purchasing power is only £345, or a deficiency of £785. This shortage arises mainly due to the fact that the wages paid out in the earlier processes are spent immediately, and only if the process is being repeated steadily and uniformly is this shortage of £785 reduced.

If then, under normal circumstances, there is a shortage of purchasing power, consumer credit which does not enter into the cost of goods and services can be issued without causing inflation. If the amount, so issued, be limited to the excess production then inflation is avoided.

Whilst the above shows how the financial system can throttle and accelerate the industrial machine by control of credit, there is a further great cause of a shortage of purchasing power. Any revenue not spent in buying consumable goods or employing available services but invested is at once converted into capital, and is no longer available as purchasing power. That capital, being invested, demands a further share in the interest that is to be paid as part of the price of future consumable goods, and so accentuates the shortage.

This point is brought out quite clearly by Mr. Vowles in his letter.

It is quite impossible to refer to other reasons why there is a shortage of purchasing power, but it is hoped that the above few sample accounts will arouse some interest in this most important question.

These various financial transactions of Y and his employees could be shown in a diagram of the Sankey loop type, but the above accounts may seem more clear to some.

It has been very noticeable in this correspondence that not one of the writers has referred to Colonel Kitson Clarke's original articles, nor have they suggested, with the possible exception of Mr. Vowles, any way by which answers could be given to Colonel Kitson Clarke's questions. Their criticism has, in most cases, been—I will not say destructive—not very helpful, and I have felt like paraphrasing a famous caption used by Bairnsfather regarding alternative accommodation.

Mr. Sumner Wells, speaking on October 6th, is reported as follows :—

> "If the dietary needs of the world's population could be satisfied to the extent necessary to meet minimum standards for sustaining health, the burdensome surpluses which normally trouble producers of many staple products would disappear. I am glad to be able to assure you that this subject is being given preferential attention by agencies of this and other Governments."

What better means of transferring the surpluses to the voids could be provided than a sufficiency of purchasing power ? If this were done, then not only would Mr. Sumner Wells' major points be handled, but the majority of the twelve questions originally raised by Colonel Kitson Clarke would no longer represent any serious problem.

Mr. Editor, I would like to conclude by thanking you for opening your columns to this correspondence, as I believe, notwithstanding Mr. Watt's remarks, that engineers are quite capable of understanding finance, and, I hope, by leading others to understand its alleged intricacies, to shed light upon one major trouble.

I. V. Robinson.

Walton-on-Thames, November 12th.

COMPOUND LOCOMOTIVES

Sir,—Whilst the gauge limitations do answer the puzzle of compound failures in this country in respect of the more modern and larger locomotives, it is less certain that they did so when engines were smaller. It is difficult to account for the comparative disappointment in the performance of the famous De Glehn "Atlantics" when tried out on the G.W.R., for they already had a splendid reputation in their own country and have since largely become the standard type for the Continent.

The Worsdell-Von Borries engines of the old North-Eastern were unsymmetrical and may have been hard on a road less able to withstand hammer blow than the permanent way of to-day.

The Webb three-cylinder system had obvious defects, though the later four-cylinder designs one might have thought would have at least passed muster, but here again there was no simpling valve to assist starting or collar work. The fact appears to remain that the Smith system on the old Midland Railway alone achieved a real measure of success provided as the engines were with means for working both simple and compound according to the conditions to be faced. Increasing train loads have now relegated these engines to secondary importance for main line express work.

Mr. Stanier tells us that the high-revolution geared reciprocating unit has little or no advantage over the geared turbine. I wonder if this stricture applies to starting torque, in which the turbine is notably deficient. The ability to reverse the reciprocating unit, one would have thought, would also be an advantage.

Unfortunately, the compound and the turbine cannot give of their best when divorced from the condenser, and here again Mr. Stanier shows us the difficulties, but there are so many ways of getting round problems of design that one is rather surprised that compounding has not developed in this country despite the handicap mentioned. For instance, a tandem arrangement of cylinders or the superposed arrangement of the Vauclain system might offer a solution.

Perhaps our better and cheaper coal has something to do with it, the complication not proving worth the extra cost when all items of running expenses are included.

It has always seemed to the writer that the evolution of a gear-box offering two speeds and the means to change them while running without shock might revolutionise locomotive performance. Admittedly the design of such a gear-box to transmit the powers involved would present a problem, but is it insoluble by the use of hydraulic or magnetic clutches ? After all, the conditions of railway traction are less arduous than those of road traction, and in the days when steam cars were popular on the road the addition of a second gear added enormously to their performance, but, of course, the difference in power involved is vast.

In short, flexible as steam power is, we seem to ask too much of it to get the best out of it for railway work, which results in a whole series of compromises in the design to get the best average results. With a gear-box, as proposed, elimination of back pressure and compound working might be obtained without prejudice to tractive effort. The design of such a change speed gear may be impracticable, of course, but if not, it would seem worthy of full attention.

S. P. Christie.

Southsea, November 18th.

Rainbow Bridge, Niagara Falls

No. II

(*Continued from page 351, November 21st*)

THE first of the grillages was erected on February 15th, 1941, and twelve days later the first rib section was secured to its skewback. The two arch ribs were completed, with the exception of their closing pieces, on May 19th, following; and final closure was effected on June 12th. Immediately thereafter the contractor started to erect the spandrel columns and the steel work of the floor system; and on August 1st, with the steel work completed, he began pouring the concrete of the reinforced deck slabs.

The depth and swiftness of the Niagara River, and the sheer walls and talus slopes of the gorge, which has its crest line 180ft. above the normal river level, made it impossible to erect the two arch ribs with the aid of supporting falsework. The situation was fully understood in drafting the specifications on which bids were asked and which were opened on March 12th, 1940. The specifications read: "It is expected that the contractor will erect the arch ribs, with their lateral bracing, by cantilevering out from both shores with the aid of tiebacks anchored in the rock cliffs." It will probably be of interest to learn how the successful contractor dealt with this problem.

Each rib, between skewbacks, is made up of twenty-four separate sections that were handled as such in simultaneously erecting each half of a rib from opposite sides of the river, as well as constructing the two ribs in unison. The sections ranged in unit weight from 49 tons to 75 tons and the prevailing length of each section was a trifle less than 39·5ft. The section attached to each skewback was somewhat shorter. A diagram of the method of erection is given on an accompanying drawing, but the following description is offered as being easier on the eyes to read and withal readier to grasp.

The same order of erection was followed at each side of the gorge in extending simultaneously the two ribs for half of the arch structure. A description of what was done at one side of the gorge will apply equally to the work carried forward at the other side. Over the outermost column of one of the concrete approach spans, for example, was reared an erection bent, approximately 130ft. high with its two legs set 56ft. 2in. apart, centre to centre. At the top and at two levels below the bent was cross braced and on the shoreward side each leg was further steadied by a strut—all this steel work consisting of bridge members that were later worked into the river crossing. The legs rested on pin bearings that permitted some longitudinal swaying. From the landward side and at the top the bent was tied by a total of thirty-two wire ropes, each strand being $1\frac{9}{16}$in. in diameter, leading to groups of concrete blocks, each weighing 650 tons, set in anchorage pits excavated in the rock about 350ft. rearward. Sufficient stress was developed in these tiebacks to pull the top of the erection bent slightly rearward in advance of attaching the forward tieback cables to any of the panel points of the rib sections. The forward tiebacks were secured to a number of groups of links, arranged one above the other, at the top and riverside of the two legs. According to the order of erection, from the approach arch outward, each lengthening rib half was held under tension by tiebacks consisting successively of eight, eight, eight, and twelve strands or ropes with a maximum of twenty strands at any one time for the half rib. Each strand at its lower end connected with a suitable number of adjustable links, and each link was secured to the top of a rib section by pins 4in. in diameter that passed through steel T sections that were fastened to the top of an arch rib with high-tension bolts $1\frac{1}{4}$in. in diameter. The length of each strand and the tension applied to it in supporting a given part of the rib was carefully predetermined and applied in practice in accordance with a chart prepared for the purpose, taking into account any cant of erection bent, the prevailing temperature, and, of course, the elevation of the section when at the prescribed position.

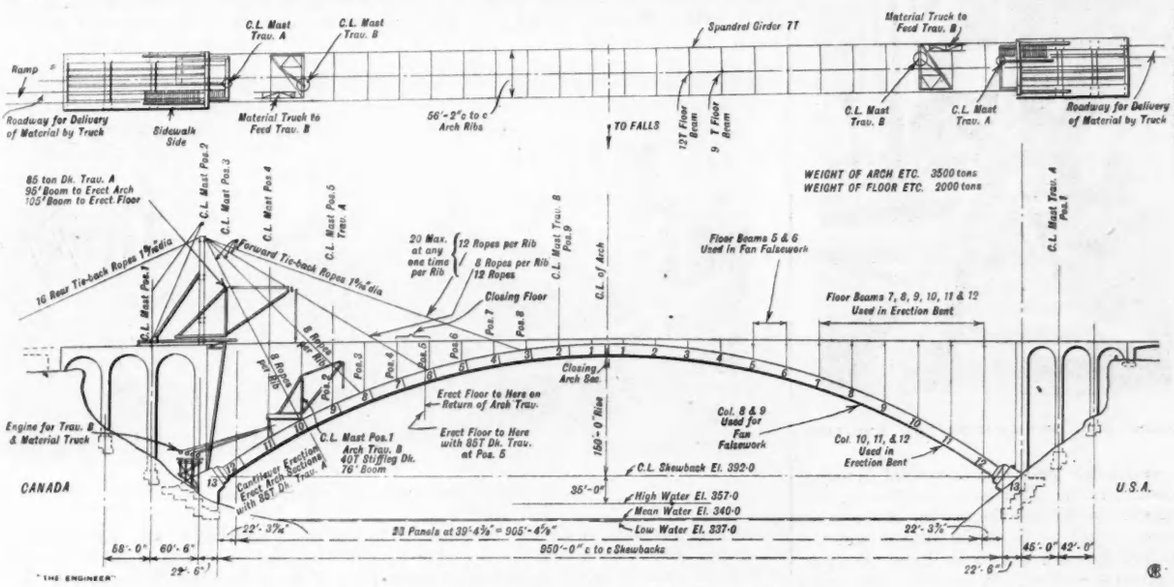
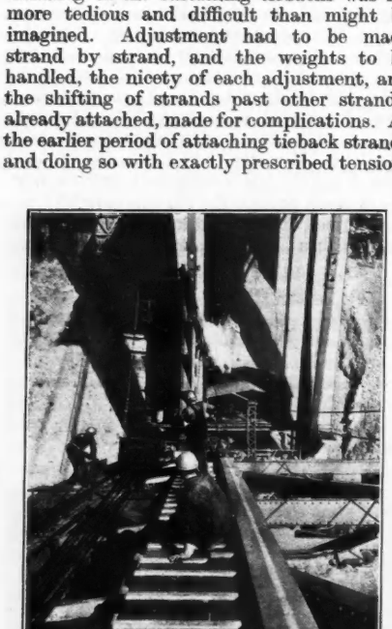

C.L. Mast Trav. A
C.L. Mast Trav. B
Spandrel Girder 7T
Material Truck to Feed Trav. B
Ramp
Roadway for Delivery of Material by Truck
Sidewalk Side
Material Truck to Feed Trav. B
56'-2"c to c Arch Ribs
TO FALLS
12T Floor Beam
9T Floor Beam
C.L. Mast Trav. B
C.L. Mast Trav. A
Roadway for Delivery of Material by Truck
85 ton Dk. Trav. A
95' Boom to Erect Arch
105' Boom to Erect Floor
C.L. Mast Pos. 2
C.L. Mast Pos. 3
C.L. Mast Pos. 4
C.L. Mast Pos. 5 Trav. A
WEIGHT OF ARCH ETC. 3500 tons
WEIGHT OF FLOOR ETC. 2000 tons
C.L. Mast Trav. A Pos. 1
16 Rear Tie-back Ropes 1⅝" dia
Forward Tie-back Ropes 1⅝" dia
20 Max. at any one time per Rib
12 Ropes per Rib
8 Ropes per Rib
12 Ropes
C.L. Mast Trav. B Pos. 9
C.L. of Arch
Floor Beams 5 & 6 Used in Fan Falsework
Floor Beams 7, 8, 9, 10, 11 & 12 Used in Erection Bent
C.L. Mast Pos. 1
8 Ropes per Rib
Closing Floor
Pos. 7
Pos. 8
Closing Arch Sec.
Erect Floor to Here on Return of Arch Trav.
Erect Floor to Here with 85T Dk. Trav. at Pos. 5
Engine for Trav. B & Material Truck
C.L. Mast Pos. 1 Arch Trav. B 40T Stiffleg Dk. 76' Boom
Cantilever Erection Erect Arch Sections with 85T Dk. Trav. A
150'-0" Rise
Col. 8 & 9 Used for Fan Falsework
Col. 10, 11, & 12 Used in Erection Bent
C.L. Skewback El. 392-0
CANADA
U.S.A.
35'-0"
High Water El. 357-0
Mean Water El. 340-0
Low Water El. 337-0
22'-3⅞"
22 Panels at 39'-4⅞" = 905'-4⅞"
950'-0" c to c Skewbacks
58'-0"
60'-6"
45'-0"
42'-0"
"THE ENGINEER"

DIAGRAM SHOWING METHOD OF ERECTING BRIDGE

ARCH APPROACHING COMPLETION

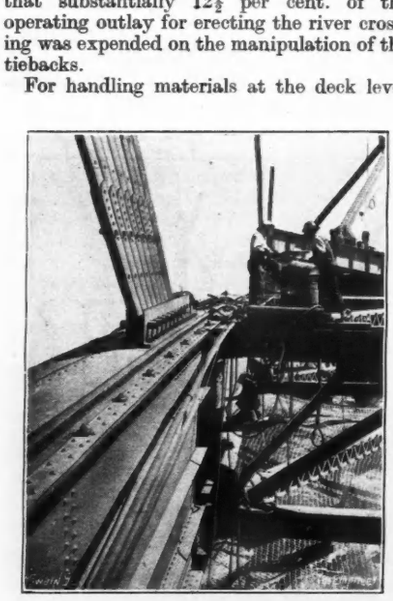
The prosecution of the work and the handling of the sustaining tiebacks was far more tedious and difficult than might be imagined. Adjustment had to be made strand by strand, and the weights to be handled, the nicety of each adjustment, and the shifting of strands past other strands, already attached, made for complications. At the earlier period of attaching tieback strands and doing so with exactly prescribed tension,



HAULING OUT RIB SECTION FOR ERECTION

the contractor made use of special dynamometers. As the ribs were lengthened and became more flexible the matter of the exact tension ceased to be so important and the principal demand was to hold the rib up at the given elevation. It has been estimated that substantially 12½ per cent. of the operating outlay for erecting the river crossing was expended on the manipulation of the tiebacks.

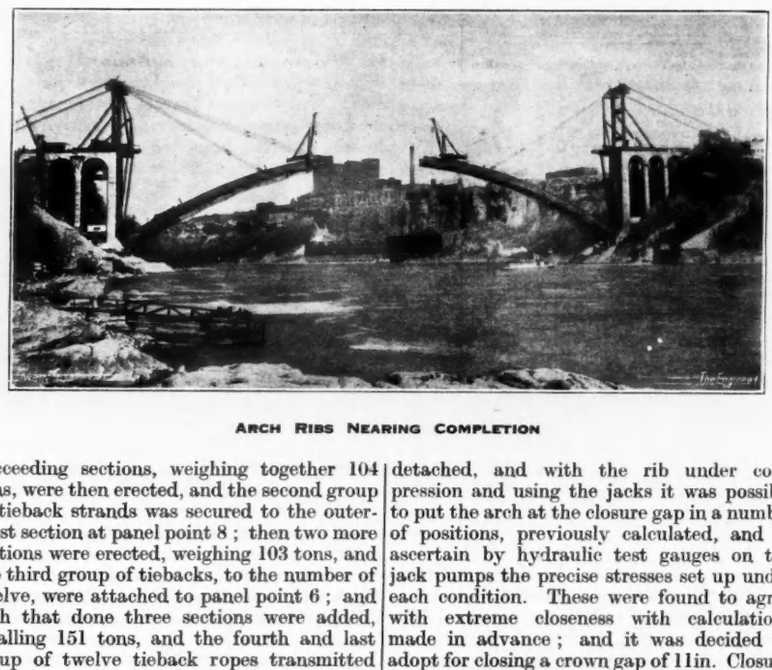
For handling materials at the deck level



ADJUSTABLE CONNECTION OF TIEBACKS TO ARCH RIB

and on the ribs two travellers were used. The 85-ton deck traveller, equipped at different times with 95ft. and 105ft. booms, was first used to erect the adjacent erection bent; next, to aid in erecting the arch, and finally, to play its part in erecting the floor. The arch traveller, operating at a lower level, carried a 40-ton stiff-leg derrick provided with a 76ft. boom. The deck traveller was in a position to pick up materials from the approach level and to pass it down to the arch traveller. Both travellers were served by a hoisting engine set up on a platform just above and between the two arch abutments. The deck traveller and the arch traveller co-operated in much of the work and alternated in certain of the concluding operations. The arch traveller was erected by the larger deck traveller and, in the end, the deck traveller was dismantled by the bigger unit.

Starting from the skewback of a rib, the initial three sections were assembled by cantilever erection, the combined weight being 198 tons, and the first group of tieback strands was attached near the outer end of the third section at panel point 10. The two

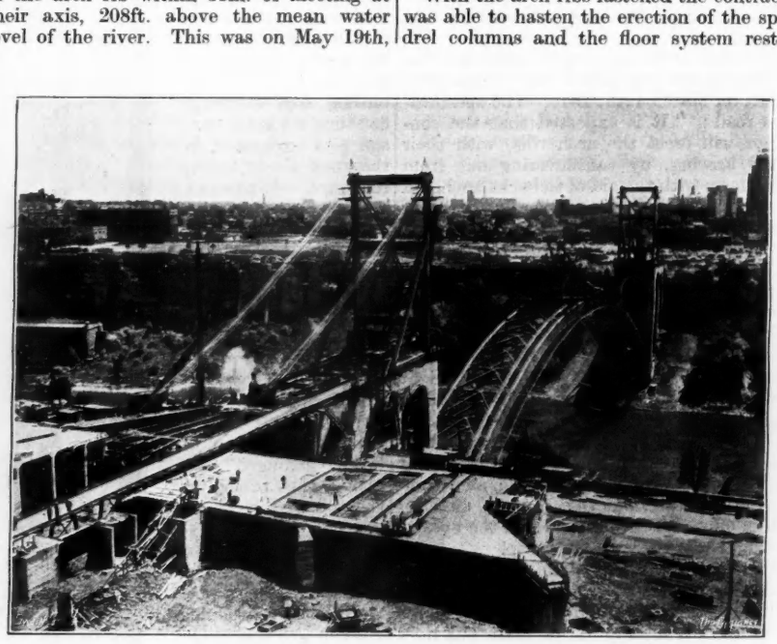


ARCH RIBS NEARING COMPLETION

succeeding sections, weighing together 104 tons, were then erected, and the second group of tieback strands was secured to the outermost section at panel point 8; then two more sections were erected, weighing 103 tons, and the third group of tiebacks, to the number of twelve, were attached to panel point 6; and with that done three sections were added, totalling 151 tons, and the fourth and last group of twelve tieback ropes transmitted the load to the erection bent. The concluding two rib sections were then added, being cantilevered from panel point 3. This brought the opposing ends of the two halves of the arch rib within 11in. of meeting at their axis, 208ft. above the mean water level of the river. This was on May 19th, 1941, and only the closure operation remained to complete the ribs.

The first step toward closure was taken during the night hours of May 27th, between midnight and 6 a.m., when temperature conditions were favourable to measuring the exact gap to be spanned by the closure pieces to be used in making each rib a single structural unit. Four 500-ton jacks, two above and two below the gap, with a suitable alignment guide, forced the adjacent rib ends 18in. apart so as to relieve to some extent the loads carried by the sustaining tiebacks of each half length of the rib. The two parts were then kept apart with blocking and the jacks released. The tiebacks were next detached, and with the rib under compression and using the jacks it was possible to put the arch at the closure gap in a number of positions, previously calculated, and to ascertain by hydraulic test gauges on the jack pumps the precise stresses set up under each condition. These were found to agree with extreme closeness with calculations made in advance; and it was decided to adopt for closing a crown gap of 11in. Closure pieces were accordingly ordered to meet that condition, and they were delivered from the shop in time for application on June 12th, 1941.

With the arch ribs fastened the contractor was able to hasten the erection of the spandrel columns and the floor system resting



CLOSURE OF ARCH, JUNE 12, 1941

on them. In a little more than a month and a half the latter steel work was all in place and it was then possible to begin placing the concrete slabs of the deck. Inasmuch as the concrete arch approaches were virtually finished before any erection work was started on the arch ribs, there remained to be done inland from those approaches only the plazas, toll booths and other buildings. It was possible to work on them even before the last of the steel was in place for the arch structure without causing interference.

High-early strength cement has been extensively used on the approach structures, and every effort has been made to protect newly placed concrete against the harmful effects of weather and temperature. This has been necessary because of the rigorous weather that ordinarily prevails in the neighbourhood of Niagara Falls during the cold months of each year. Similarly, concrete poured in the summer time in that region has to be shielded from the sun.

The Rainbow bridge has been built under the direction of the Niagara Falls Bridge Commission, called into being by the joint action of the State of New York and the Province of Ontario. The Commission was empowered to finance the undertaking by revenue bonds issued to the amount of 4,000,000. The members of the Commission, eight in number, were appointed by the interested Governments, four by the State of New York and four by the Province of Ontario. The Honourable T. B. McQuesten, K.C., is Chairman, and the Executive Secretary is C. Ellison Caumeyer. The designing engineers are Waddell and Hardesty, New York City, who have collaborated as consulting engineers with Edward P. Lupfer Corporation, Buffalo, N.Y. The Bethlehem Steel Company, Bethlehem, Pa., was the contractor for the steel arch span and also the erector, with the Canadian Bridge Company, of Walkerville, Ont., associated in the fabrication of such of the steel work as could be manufactured in Canada. Aiken and McLachlan, Ltd., of St. Catherines, Ont., was the contractor for the foundations and the concrete approaches on the Canadian side of the river. The McLain Construction Company, Buffalo, N.Y., was the contractor for the foundations and the concrete approach on the New York side of the waterway. The traffic engineers have been Parsons, Klapp, Brinckerhoff and Douglas, New York City. On the Canadian side the approaches have been financed and constructed under the Ontario Highway Department; and the corresponding service at the New York side has been performed by the New York Frontier Park Commission.

The site for the Rainbow bridge was dedicated by their Majesties King George VI and Queen Elizabeth, while the Royal couple were in the United States and Canada during 1939. Ground for the bridge was broken May 16th, 1940, and the first steel was put in position and dedicated by the Honourable T. B. McQuesten, February 17th, 1941.

Machine Tools for Production of Small Arms

WE illustrate herewith certain machines, made by the Builders Iron Foundry, Providence, R.I., U.S.A., for drilling, reaming, rifling and chambering the bores of rifles, machine guns and revolvers. For these machines Alfred Herbert, Ltd., Coventry, has been appointed sole agent.

The two-spindle drilling machine, Fig. 1, will, it is claimed, drill deep holes accurately and economically. Each of the two spindles, driven by belt from its own motor, is provided with a chuck for gripping the work and revolves at a fixed speed of 1500 r.p.m. At the opposite end the work is supported in two movable bushed supports, which also carry bushings to pilot the drills. The drills are held in a collet in each tailstock and are supported by a bushed steady rest sliding on the machine ways. Feed to each tailstock is derived from an individual lead screw and half nut and is varied by means of pick-off gears which provide a range of twelve feeds. Hand operation is also provided to the tailstock. To prevent drill breakage an adjustable friction clutch in the headstock can be set to slip when the torque becomes excessive, thus stopping both spindle rotation and feed of the tailstocks. This clutch may also be engaged by a hand lever or a dog may be set to release the clutch automatically at any desired point. Two high-pressure gear pumps, driven by the spindle motors, convey cutting lubricant to the tailstocks and thence through oil tubes in the drills to the cutting edges. Oil guides in the work support return the oil to the chip pan, where it is strained before re-circulation.

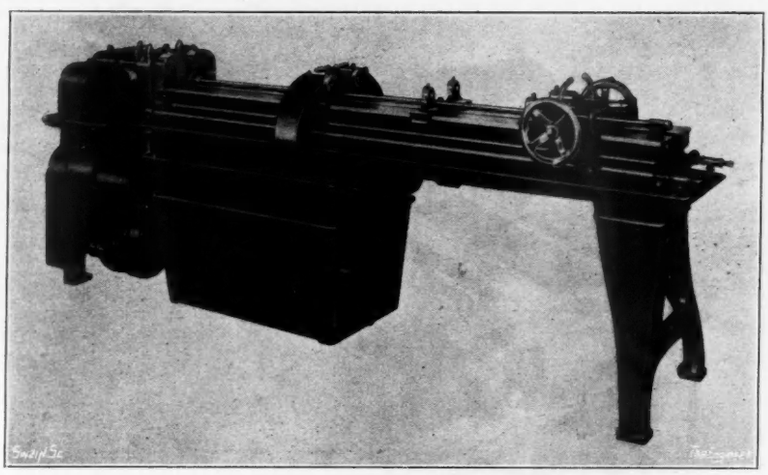


FIG. 1—DRILLING MACHINE

The machine will drill deep holes up to 0·875in. diameter, 42in. or 20in. long, according to the length of the bed. In addition to rifle drilling, the machine can be used for drilling aero and automobile camshafts, spindles and other similar work.

In the deep hole reaming machine, Fig. 2, the work is carried on a simple rest and held in a swivelling clamp, allowing the necessary amount of float but preventing rotation. The rests and

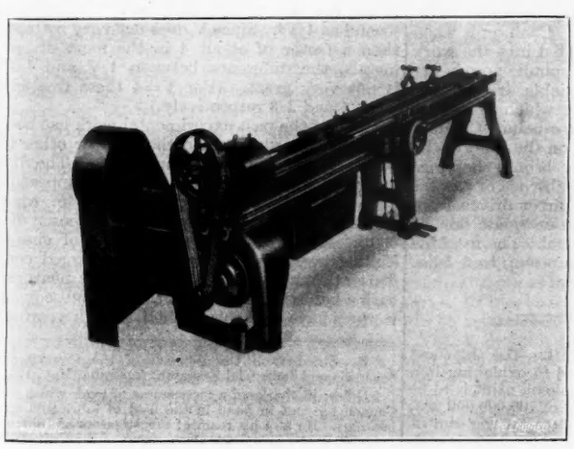


FIG. 2—REAMING MACHINE

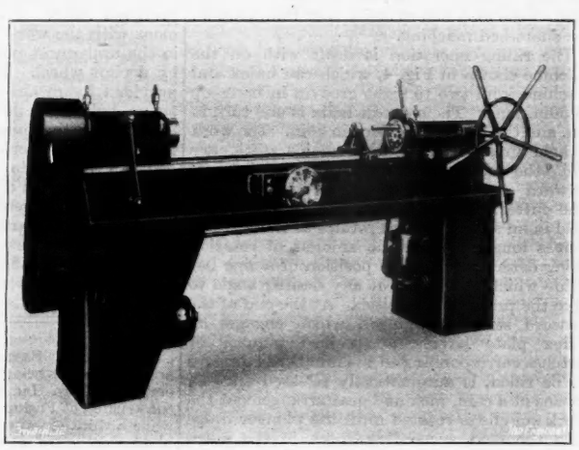


FIG. 3—CHAMBERING MACHINE

clamps are mounted on two carriages, which can be moved along the bed independently or together. The shanks of the reamers are passed through the previously drilled holes in the work and are held in a chuck on each of the spindles, the cutting portion projecting beyond the work. With the spindles rotating the carriage feed is engaged to move the work away from the headstock. The drive is by a 5 H.P. motor, through vee belts to the main shaft in the headstock to which each of the two spindles is geared. Three speeds are provided by interchangeable motor pulleys. A second shaft geared to the spindles drives the feed shafts through idler gears. Pick-off gears provide twelve rates of feed. Each of the carriages is reciprocated by rack and pinion, the drive being transmitted from the feed shafts through bevel gears, worms and wheels and clutches. A clutch control enables either or both carriages to be moved under power in each direction, and automatic stops can be set to trip the feed of the carriages at any point. A hand feed is also provided. Two foot pedals at the centre of the bed can be used to start or stop either of the spindles through a clutch. A supply of cutting lubricant is conveyed through the reamers to the cutting edges in a similar manner to that of the system on the drilling machine. The reaming capacity is 0·875in. diameter by 50in. long on the long bed machine and 19in. long on the short bed machine.

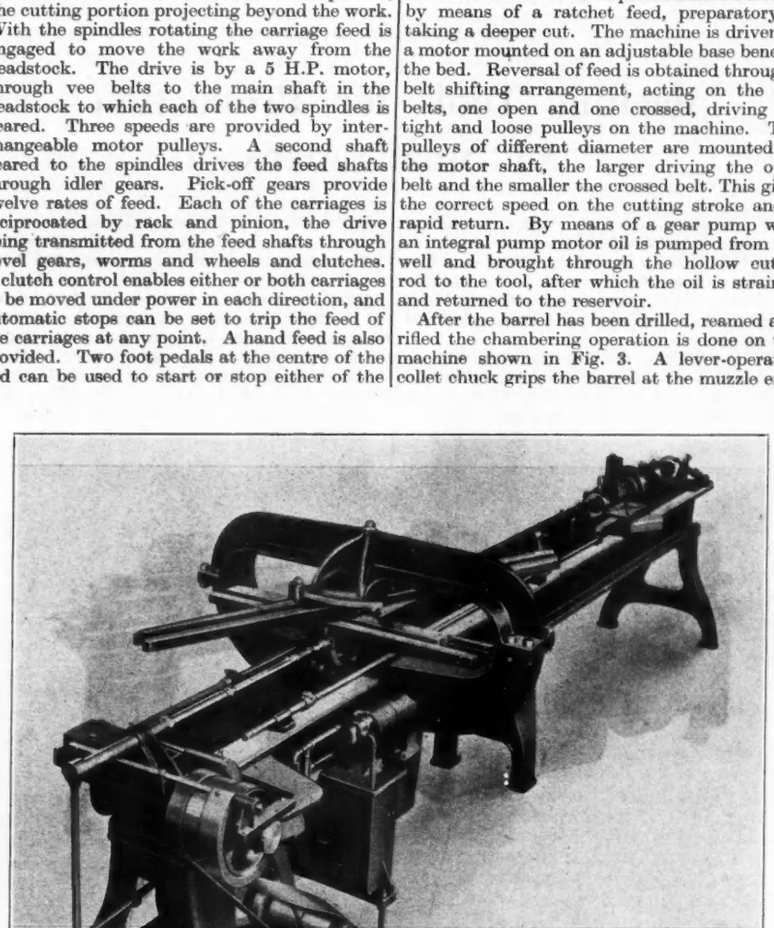


FIG. 4—RIFLING MACHINE

The rifling operation is dealt with on the machine shown in Fig. 4, which can index and machine from two to eight grooves in bores up to 50in. long. The shortest helix is one turn in 8in. and the longest one turn in 20in. The work is held in a chuck which remains stationary while the cutter passes through the work on its forward stroke, cutting on the return stroke. The cutter, supported by a stationary rest, is held in an adaptor which rotates as the carriage moves longitudinally, the amount of rotation being determined by the position of a sine bar guide which can be set at any desired angle to give the proper rifling pitch. At the end of the forward stroke a plunger, which engages an index plate having a specified number of notches corresponding to the number of grooves to be rifled, is automatically released and, by means of a cam, rack and gear arrangement the work spindle is rotated until the plunger drops into the next succeeding notch in the index plate. A special mechanism automatically moves the cutter out of position at the beginning of the forward stroke, at the end of which stroke the cutter is forced back into position preparatory to the cutting stroke. At the end of each complete revolution of the index plate the cutter is moved out a predetermined amount by means of a ratchet feed, preparatory to taking a deeper cut. The machine is driven by a motor mounted on an adjustable base beneath the bed. Reversal of feed is obtained through a belt shifting arrangement, acting on the two belts, one open and one crossed, driving the tight and loose pulleys on the machine. Two pulleys of different diameter are mounted on the motor shaft, the larger driving the open belt and the smaller the crossed belt. This gives the correct speed on the cutting stroke and a rapid return. By means of a gear pump with an integral pump motor oil is pumped from the well and brought through the hollow cutter rod to the tool, after which the oil is strained and returned to the reservoir.

After the barrel has been drilled, reamed and rifled the chambering operation is done on the machine shown in Fig. 3. A lever-operated collet chuck grips the barrel at the muzzle end, the breech end being supported in an adjustable steady rest. A turret slide which is adjustable along the bed is equipped with eight quills carrying collets to hold floating chambering reamers. The turret is indexed by a lever, a precision index plate assuring accurate alignment with the work spindle. Each quill when in the uppermost position is fed into the work by a pilot wheel. Thirteen spindle speeds are provided by means of a variable drive mechanism below the headstock, which transmits the drive to the spindle by vee belts. Changes are made by a lever and dial on the front of the bed. The spindle runs in bronze bearings ensuring a smooth drive and absence of chatter in the work. A gear pump direct driven from a separate motor provides an adequate flow of oil into the muzzle of the barrel. The machine illustrated in Fig. 3 will chamber up to 0·50in. calibre barrels up to 50in. long.

HOW JAPAN EXPLOITS CHINA.—The Japanese are reported as being interested in exploiting iron ore in Southern Hainan. A shale oil plant is to be constructed at Fushun at a cost of 100,000,000 yen, while a third enterprise is the new Antung cement plant which was due to commence operations in mid-September with a capacity of 150,000 metric tons annually.

The Contact of Colliding Surfaces*

By F. P. BOWDEN, Sc.D.,† and D. TABOR, Ph.D.‡

INTRODUCTION

EARLIER papers (Bowden and Leben, 1939; Bowden and Tabor, 1939) have described the nature of contact between sliding metal surfaces. The area of contact does not remain constant, and it is clear that an intermittent clutching and breaking away may occur at the points of contact of the sliding solids. This is accompanied by a considerable amount of plastic derfomation of the surface irregularities and of the metal itself. If the load or the sliding speed is sufficiently great, the surface temperature may rise to a high value (Bowden and Ridler, 1936).

This paper discusses the nature of contact between colliding surfaces. This is of both theoretical and practical importance. In a running engine, bearing, or gear, vibrations will be set up and rapid changes may occur in the normal components of the force between the surfaces. These may play an important part in changing the area of contact and in influencing the friction and wear of the surfaces. The following experiments were undertaken to investigate the nature of contact between colliding metals by a measurement of the change in electrical conductance during impact. In some cases the temperature produced at the region of contact during the instant of collision was also measured.

St.-Venant (1867) suggested that the time of impact t is determined by the time required for a compression wave to travel through the solid and be reflected back again. In the case of two bars of equal length L impinging on their flat ends, $t=\frac{2L}{V}$, where V is the velocity of a compression wave in the material. A different approach to the problem is that due to Hertz (1881). He assumed that a local compression at the region of contact takes place elastically and subsides reversibly. By applying his equations for reversible (elastic) deformations, Hertz was able to show that $t=k\,r/v^{\frac{1}{5}}\,V^{\frac{1}{5}}$, where k is a suitable constant depending on the physical properties of the bodies, r is the radius of curvature at the region of contact, and v is the velocity of approach of the bodies. For this hypothesis to be valid the deformation during collision must be elastic, and the time of impact must be large compared with the time for a compression wave to travel along the bodies and back again.

The main differences in the results of these two theories are that in St.-Venant's theory, t is independent of the radius of curvature of the contacting ends and of the velocity of approach, but is proportional to the length of the colliding bodies; whereas in the Hertz theory t is proportional to the radius of the contacting ends and to $1/v^{\frac{1}{5}}$ and is independent of the length of the bodies. The other variable V is not a very critical test of the theories, since in the first theory it occurs as $1/V$ and in the second as $1/V^{\frac{1}{5}}$. Since V does not vary by more than a factor of about 4 in the most diverse metals, the difference between $1/V$ and $1/V^{\frac{1}{5}}$ is not very great. (For V=4 these fractions are 1/4 and 1/3 respectively.)

Much of the past experimental work has been directed towards proving that one or other or both of these theories are applicable. The first measurements on the time of impact appear to have been made as long ago as 1845, when Pouillet suggested the use of a condenser discharge method. Here the amount of charge leaking away from a battery or charged condenser through the contacting bodies is measured with a ballistic galvanometer. Most subsequent workers have used this method, though a certain

* Reprinted from the *Journal* of the Council for Scientific and Industrial Research, Australia, May, 1941.

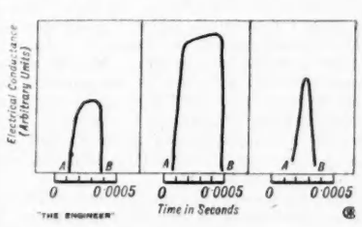
† Officer in charge of a programme of work which the Council has put in hand in the field of lubricants and bearings. He and his team of investigators are accommodated in the Chemistry Department of the University of Melbourne.

‡ An officer of Dr. Bowden's section.

number of workers have measured t by optical means.

Schneebeli (1871, 1872, 1885), Tait (1900), Dinnik (1906), Ramsauer (1909), and Kennelly and Northrup (1911) obtained confirmation of Hertz's equations by the condenser discharge method. Raman (1920) obtained further confirmation of this theory from measurements of rebound. Sears (1908) and later Wagstaff (1924) showed that for short bars Hertz's theory held almost exactly, whilst for long bars St.-Venant's theory was more applicable. On the other hand, Tschudi (1921) found that the Hertzian theory held for cast iron and brass spheres. He did not, however, find that St.-Venant's theory would explain his results for long bars (1924). Experiments of a different kind were carried out by Moreau (1920) and Rebuffé (1936) using the condenser-discharge method, and by Okubu and Hara (1928) using an optical method. These workers attribute a large fraction of the time of collision to the passage of the bodies through a thin film of air at their surfaces.

A series of valuable papers by Andrews



FIGS. 1, 2, AND 3

appeared from 1929 to 1931. He determined the time of impact by the partial discharge of a condenser. In his first paper (1929) he showed that for most soft metals $t=t_0+a/v^n$, where n is nearly $^1/_5$. He also suggested that there is a minimum velocity v_0 needed just to initiate flow of the material. In his second paper (1930) he constructed a theory which agreed satisfactorily with his observations. The time of impact was considered to be made up of three parts—an initial elastic deformation, a subsequent plastic deformation, and finally the elastic relaxation of the edge of the deformed region. In his third paper (1931) Andrews used Raman's optical method of measuring small velocities of approach and separation, but still used the condenser method of determining t. He showed that for velocities of approach less than 2 centimetres per second the time of impact accurately obeys Hertz's equation $t=a/v^{\frac{1}{5}}$, and that below a definite velocity, specific for each material, the coefficient of restitution is unity, implying that below these velocities only elastic deformation occurs. He also showed clearly that for high speeds of collision neither Hertz's nor St.-Venant's theory is applicable. In this case it is the plastic flow pressure of the material which determines the period of impact.

In most of these experiments the period of impact has been determined by the condenser-discharge method. This method is simple, but suffers from the disadvantage that it merely gives the total time of impact. It does not indicate the way in which the area of contact varies during the collision itself. In the following experiments, the nature of contact and the area of contact during impact were studied by measuring the electrical conductance between metal surfaces during their collision. When the surfaces are separated, the conductance is zero. As they come together during collision the conductance rises to a maximum and then falls off again as they come apart. The conductance at any instant is a measure of the area of contact. A cathode ray oscillograph was used to record the changes in electrical conductance.

The results described in this paper represent a preliminary investigation of the problem. Most of the experimental work was carried out in the Laboratory of Physical Chemistry, Cambridge (Tabor, 1939). A more complete and thorough study was being carried out in collaboration with Mr. W. Hirst, but was interrupted by the war. It is considered, however, that the preliminary results already obtained are of sufficient interest to warrant publication.

Experimental

Spherical Surface on Plate.—In the first series of experiments a mild steel sphere, about 2 cm. radius, was allowed to collide with a massive mild steel plate. The sphere was mounted on the lower end of a steel bar of ¼in. square section and about 80 cm. long. The top end of the bar was pivoted on ball bearings mounted at the top of a concrete column so that the sphere could swing freely as a rigid pendulum. The other surface was a flat steel plate, 1in. thick, and a foot square. This was clamped in a vertical position on to the bottom of the concrete column, so that the collision occurred normally to the surface. When the sphere was at rest it was just in contact with the surface of the plate. The suspended system was equivalent to a simple pendulum of length about 60 cm., with a mass at the end of about 1000 g. The velocity of impact used was of the order of 100 cm. per second. The steel surfaces were finely ground and unlubricated.

The cathode ray trace of the conductance showed that the time of impact was quite long. It extended over several thousandths of a second. The trace during this interval was very complex, and it was apparent that the vibrations set up in the plate and in the bar by the collision caused very complex changes in the area of contact during the period of impact. It was clear that rapid subsidiary makes and breaks were occurring at the points of contact during the whole time of collision.

Sphere on Sphere.—The experiment was then repeated with metal spheres. These were

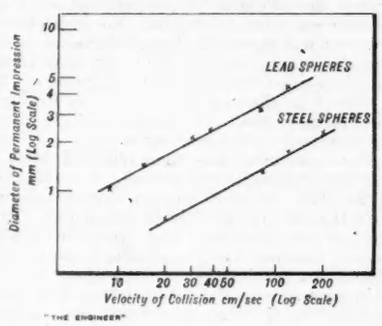


FIG. 4

freely suspended so that any secondary vibrations were reduced to a minimum. The mechanical arrangement was similar to that used by Andrews. Each sphere was mounted on a short steel rod about ¼in. diameter passing through a vertical hole bored through a diameter. A short bar was fixed at right angles across the top of the rod and at each end of the bar two fine steel wires were attached to form a V-shaped suspension. Each sphere was thus suspended by four wires and could swing freely with a minimum of rocking or vibration. The suspension was so adjusted that, when at rest, the spheres were just in contact. One of the spheres could be drawn aside and released by an electro-magnetic trigger. The spheres could be rotated about the vertical rod so that they presented fresh portions of the surface for each collision. With this arrangement the secondary variations due to vibrations of the suspension are almost eliminated.

The Nature of Impact and the Time of Collision

If the deformation during the collision were elastic, we should expect the conductance to rise to a maximum as the surfaces approach and to fall off again as they separate in a symmetrical curve. If plastic deformation occurs, the curve will be asymmetric.

Fig. 1 shows a typical curve obtained with mild steel spheres. The mass of each sphere was 250 g., and the velocity of the moving sphere at the instant of impact was 76 cm. per second. Contact begins at the point A, the area in contact increases to a maximum, and then falls off as the spheres separate. At B it has again fallen to zero. The total time of impact is 3×10^{-4} sec. It is clear that the curve is not symmetrical. The break occurs much more rapidly than the make.

Fig. 2 shows the result of a similar experiment carried out with lead spheres. The mass of each sphere was 370 g., and the velocity of impact 76 cm. per second. The time of impact is longer (4×10^{-4}), but the shape of the curve is similar to that observed with steel spheres. The break is much more rapid than the make, and it is clear that plastic deformation has again occurred.

Some further experiments were carried out by Mr. W. Hirst, using spheres made from very hard tool steel. The result obtained by him for a low velocity collision is shown in Fig. 3. The velocity of impact was of the order of 10 cm. per second. It will be seen that the conductance curve of the make and break is nearly symmetrical, showing that the collision is more nearly elastic. The time of impact was about $1\cdot5\times10^{-4}$ sec. At higher collision velocities (one or two metres per second), however, even with this steel the conductance was asymmetric. The time of make was considerably larger than

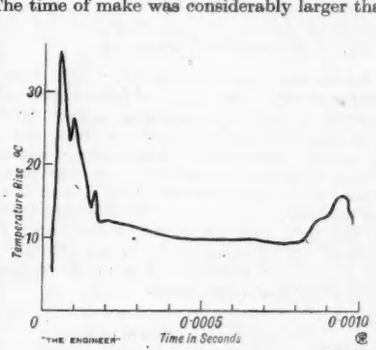


FIG. 5

the break, showing that plastic deformation occurs.

In these experiments the absolute value of the electrical resistance during impact was not measured with accuracy. It varied from infinity at the bottom of the trace to a very small fraction of an ohm at the top. For this reason no attempt is made here to calculate from the conductance, the absolute area of contact.

Discussion

According to the Hertzian theory of elastic deformation, the time of impact t should vary as the one-fifth power of the velocity of impact v, and most workers using the ballistic method have found that a relation of the type $t=a+b\,v^n$ does hold, where n is of the order of $^1/_5$. It is clear, however, that according to this relation the rate of variation of t with v is very slow. Thus in the experiments described above, where v varied from 2·4 cm. to 85 cm. per second (*i.e.*, thirty-five-fold), the Hertzian time of impact would only vary at the most by a factor of 2. This variation falls within the range of the reproducibility obtained in these experiments, so that it is difficult from measurements of t to decide whether the Hertzian equation is obeyed. An examination of the cathode ray trace, however, shows clearly that the deformation cannot be purely elastic. The asymmetric shape of this trace shows that plastic deformation occurs during the collision. It is also clear that the time of impact for steel on steel is appreciably smaller than for lead on lead. For steel spheres the values of t were mainly grouped between $1\cdot5$ and 3×10^{-4} sec., whereas for the same velocity range the values of t for lead spheres were mainly grouped between 5 and 10×10^{-4} sec. Although these values of t are roughly in the same ratio as the velocity of a compression wave in the two metals concerned (5×10^5 cm. and $1\cdot3\times10^5$ cm. per second respectively), a simple calculation shows that the times of collision by the compressional theory of St.-Venant would imply values of t nearly one-tenth of those observed. All these considerations show that the process of collision cannot be purely elastic. If we assume that the process of collision involves only plastic deformation, we can calculate the period of collision. We

assume that there is a constant dynamic flow pressure P and that the struck sphere does not move until the whole of the plastic deformation has occurred.

If the spheres are of equal mass M and of radius R, and x is the depth of the impression in each sphere at any instant, the area of the flowed cap over which contact is occurring is πa^2, which is very nearly equal to $\pi\, 2\,R\,x$, so that the force opposing motion is $P\,\pi\,2\,R\,x$. If we consider the centre of the struck sphere as the fixed origin, the distance of the moving sphere from this origin at this instant is $2\,R - 2\,x$.

Hence

$$P\,\pi\,2\,R\,x = M\frac{d^2}{d\,t^2}\left(2\,R - 2\,x\right)$$

Thus

$$\frac{d^2x}{d\,t^2} = -\frac{P\,\pi\,R}{M}x, \text{ or } x = A\sin\sqrt{\frac{P\,\pi\,R}{M}}\,t.$$

We see that when $t=0$, $x=0$. Also the moving sphere comes to rest when its velocity is zero,

$$i.e., \text{ when } d\,x/d\,t = 0,$$

$$i.e., \text{ when } t = \frac{\pi}{2}\sqrt{\frac{M}{P\,\pi\,R}}$$

As Andrews has pointed out, if the bodies were perfectly plastic, *e.g.*, of putty, after this interval of time the impinging sphere would have been brought completely to rest, and if the spheres then separated the time of impact would be given exactly by this expression. If we insert the constants for M, R, and P we can calculate t, as shown in the following table. P, the flow pressure of the metal, may be obtained from a measurement of the diameter of the permanent impression left in the spheres after the collision (see later).

Type of collision.	Time of impact.	
	Calculated value of t.	Observed value of t.
Steel on steel ...	1×10^{-4} sec.	1·5 to 3 $\times10^{-4}$ sec.
Lead on lead ...	4×10^{-4} sec.	5 to 10 $\times10^{-4}$ sec.

The agreement is reasonable.

It is interesting to note that in the equation obtained above t is proportional to $(1/P)^{\frac{1}{2}}$, whereas in the equation due to St.-Venant t is proportional to $(1/E)^{\frac{1}{2}}$, where E is Young's modulus. Now E and P are strength properties of the material and these often vary together. It is therefore quite possible for the time of impact to appear to vary with the speed of compression waves in the materials, yet not to vary with the lengths of the bodies, nor to agree with the actual values derived from St.-Venant's equation.

The above results show that during collision plastic flow of the metal takes place. It is only when the spheres are made of specially hardened tool steel and the collision velocity is kept low that the collision is more nearly elastic.

Size of Permanent Impression

For velocities of approach of the moving sphere which exceeded a few centimetres per second, the spheres showed permanent impressions after collision. These impressions were circular and were essentially the same for both the striking and struck spheres. If the mean diameters of these impressions are plotted against the velocities of approach on logarithmic ordinates, the results give straight lines of slope about a half. These are shown for lead and steel spheres in Fig. 4.

If we assume that there is a constant specific pressure P which just causes the surfaces to flow during impact, this result has a simple explanation :—If R is the radius of the spheres and a the radius of the final impression left in each sphere, it can easily be shown that the work expended on both spheres in producing these impressions is $P\,a^4/2\,R$. Apart from the energy lost as frictional heat, this work must be equal to the kinetic energy lost by the spheres during impact. If M is the mass, v the velocity of approach, and e the coefficient of restitution, the kinetic energy lost during impact is $\frac{1}{4}\,M\,v^2\,(1-e^2)$.

Hence

$$\tfrac{1}{4}\,M\,v^2\,(1-e^2) = P\,a^4/2\,R.$$

It is found that e varies somewhat with v, but $(1-e^2)$ remains essentially constant over the velocity range considered. Thus a is proportional to $v^{\frac{1}{2}}$. This explains the results shown graphically in Fig. 4.

If we use the above equation to calculate P, we find that the values obtained are not very different from those obtained in static tests. The dynamic flow pressure turns out to be not more than 20 per cent. greater than the static values. From general considerations one might have expected that this difference would have been appreciably greater. Edwards (1918) and Moreau (1920) have also found that in some circumstances the static and dynamic values may agree quite closely, but Vincent (1900) obtained dynamic values which are nearly double the static values. In these earlier experiments, as in most technical work on impact testing, a hard spherical body is driven into the rigidly held specimen, so that inaccuracies are introduced due to the deformation of the penetrating sphere and due to the energy absorbed by the rigid supports. These energy losses may be quite high, as Southwell has shown. In the experiments on colliding spheres, however, the energy absorbed by the extraneous parts of the system is negligible, and since the spheres are of the same material the deformation of both bodies is essentially the same. This method therefore offers an interesting method of investigating the dynamic properties of materials.

The Effect of a Lubricant Film

A thin film of caprylic acid was added to the surface of the mild steel spheres, and the nature of the impact investigated. It was possible that the polar nature of the acid molecule might change the adhesion between the spheres and so alter the time of impact. No such effect, however, was observed. The conductance curve and the time of impact were very similar to those observed with unlubricated surfaces. It is clear that electrical contact occurs through the lubricant film. The nature and the time of the impact are not sensibly altered.

The experiment was then repeated with a thin film of medicinal paraffin oil. The viscosity of this (120 centipoise) was considerably greater than that of caprylic acid (6 centipoise). The conductance never rose above zero during the impact, showing that no metallic contact took place. An examination of the surfaces of the mild steel spheres showed that they had been flattened by the force of the collision. If the spheres were allowed to remain touching, or were gently rubbed together, metallic contact was made through the oil film.

These results suggest that the reason for the failure to make contact during collision is a hydrodynamic one. The prevention of metallic contact is not due to the adsorption of the lubricant or to its surface properties, but simply to its viscosity. The impact time is so short that the oil is not able to escape from between the surfaces. In this time the metal surfaces are appreciably and permanently deformed, and undergo plastic flow, so that the tangential forces involved must be enormous. In the case of caprylic acid these forces are sufficient to squeeze out the film of acid completely, or if a thin film remains it is a relatively good conductor. In the case of paraffin oil, however, there is not sufficient time during the impact for the oil film to be squeezed out and the electrical conductance remains low, even during the collision.

This observation with paraffin oil is of considerable interest. It shows that if momentary bumping or bouncing occurs between surfaces which are lubricated with a film of mineral oil, enormous forces may be transmitted through the oil film. These forces may be sufficient to cause permanent deformation and damage of the moving steel surfaces, even though no metallic contact takes place. Although the damage under these conditions may be considerable, it will be less than would be the case if the metal surfaces came into intimate contact.

When the surfaces are sliding under conditions of boundary lubrication, the viscosity of the lubricant is of little significance. It may, however, be of primary importance if vibration is present so that impact occurs between the moving surfaces. For example, in a journal bearing which is subject to vibration, or in the lubrication of fast-moving gear teeth, the viscosity may under some conditions be the major factor. If the viscosity is sufficiently high, it may prevent the impacting surfaces from touching. The viscosity of many liquids is a function both of the pressure and of the rate of flow. It is clear from these observations that under impacting conditions it would be advantageous to select as a lubricant a liquid the viscosity of which rose to a high value when the pressure or the rate of flow was great. Even though contact is prevented, the forces transmitted through the oil film may cause some distortion and damage of the metal surfaces.

Temperature of Impact

Some experiments were carried out to see whether any appreciable temperature is generated at the region of contact during collision. This temperature should be observable as a thermal E.M.F. if the colliding bodies consist of dissimilar metals. Such measurements will, of course, only show the temperature whilst the bodies are actually in contact. The temperature rise will not necessarily be the same over the whole area of contact. At the centre of this area, for example, where the greater part of the kinetic energy is absorbed, it may be greater than at the edges. The measured thermal E.M.F. will be the integrated effect of all the thermo-couples formed by the parts of the surfaces which are in contact. It is apparent that many points on the surface may be at a temperature higher than that indicated by the measured E.M.F.

Experiments were first carried out with a steel sphere colliding with one of constantan. It was observed that with smooth spheres colliding at a comparatively low velocity, the thermal E.M.F., *i.e.*, the temperature rise, was small. For example, with spheres of mass 250 g. colliding with a velocity of 100 cm. per second, the temperature rise was only a few degrees. It was thought that this was partly due to the fairly large area of contact formed on impact, which allowed the heat to flow away very rapidly. Further, as the calculations of the dynamic flow pressure show, most of the energy of collision must be used up in permanently deforming the spheres, so that any remaining energy liberated as heat must be quite small. Some measurements were therefore attempted, using a fixed metal point on which the moving sphere impinged. In this case the area of contact for a given deformation is relatively small, and, further, one would expect more frictional heat to be generated at the surface of the point as it penetrates the sphere.

The general results showed that the temperature rise was very rapid, and that as a rule it fell to half its maximum value in about 10^{-3} sec. After this, the behaviour was very erratic, probably due to chattering in the support holding the metal point, so that the total thermal record was quite protracted. A typical result for a Woods metal sphere striking the point of a constantan cone is shown in Fig. 5, where these characteristics are clearly seen.

These experiments suggest that the temperatures generated at the region of contact of smooth metals colliding at a low velocity may be small. If, however, sharp points are present so that the deformation is restricted to a small area, and the shape of the bodies is such that an appreciable fraction of the energy of collision is used up as frictional work, the momentary temperature rise may be high, even at low collision velocities. If the bodies are non-metallic and possess a low thermal conductivity, or if particles of sand or grit are present between the surfaces, we may expect the local temperature rise to be correspondingly greater.

A Plant for Wattle Wood Pulp.—After considerable research work carried out by Mr. E. A. Ritter, of Durban, with the help of the Natal Estates, Ltd., in the manufacture of a sulphate pulp from waste wattle wood for use as wrapping paper and cardboard, a start has been made locally to produce this wattle wood pulp on a commercial scale. It is understood that the necessary plant and machinery is available in the Union, its estimated cost being about £100,000.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Non-ferrous Metals in Wartime

The war demand has naturally given a great stimulus to the production of non-ferrous metals in practically all countries which possess deposits, since consuming countries are very largely cut off from the chief producing countries. Amongst the important raw materials needed by the belligerent countries manganese ore takes an important position, and the exports of manganese from Brazil, for instance, through Rio de Janeiro, according to the *Foreign Commerce Weekly*, the organ of the United States Department of Commerce, totalled 231,000 tons in the first eight months of this year. At the end of August stocks totalling 112,154 tons were held at Rio. Cuban exports of manganese ore rose from 62,248,586 kilos. in the first six months of 1940 to 110,642,687 in the corresponding period of 1941. Chromite was exported to the extent of 38,836,802 kilos. and the exports of hematite and magnetite ore totalled 5,200,000 kilos. in the January to June period of 1941. The demand for lead has resulted in mines in many places being restarted. In Guatemala the mines are now being worked, although in normal times the low lead content of the ore and the inaccessibility of the deposits prevents profitable operation. Copper mines in the Agua Prieta district are approaching capacity production and mines which have been closed for several years are being opened. The difficulties Swedish trade has experienced as a result of the war have been referred to recently, and efforts are being made to increase the domestic production of materials which are difficult to obtain. It is probable that copper will be mined at Rackejaure, which is the largest unit in the Skellefte mining field, where investigations have revealed new deposits. Supplemental equipment, dwellings for workmen and preparatory work in the mines are necessary to establish a concentration plant at this point. The mining of copper at Rackejaure is expensive and the project is regarded as a temporary measure to bring some relief to the Swedish demand for copper. A factory for the extraction of aluminium from Swedish andalusite (obtained as a by-product at the Boliden gold plant) is to be built through State co-operation.

The Pig Iron Market

The pig iron position in Great Britain is satisfactory on the whole. The Control showed considerable foresight in conserving stocks when supplies were ample, and now that in one or two cases a stringency—it is certainly not a scarcity—has developed, consumers are reaping the benefits of a conservative policy. The foundry iron position is comfortable, and the production of high-phosphoric pig iron would appear to be in excess of the demand, but this is largely because the light castings industry is not working full time, and it has only been found possible partially to employ these foundries upon war work. As a consequence, there are good stocks of high-phosphoric pig iron in the country, and firms using this description of pig iron find their full requirements are easily covered. The position in the hematite section of the market is somewhat puzzling to many consumers. The tightness which developed a month or two ago was understood to have been remedied, although the majority of users found that the Control continued to keep a tight hand upon distribution. When imports of iron and steel and pig iron from the United States were cut down the British industry was thrown upon its own resources for hematite. The Control, however, had foreseen the position and had managed to accumulate considerable stocks, and it is from this source, plus the home production, that future hematite requirements will be met. Owing to the fact that the present consumption of hematite is almost entirely for steel required for war purposes, prompt delivery has been possible, and no doubt this has created amongst consumers the idea that the position is easier than it is. The hematite supply position, whilst needing the careful handling of distribution, does not occasion concern.

Scotland and the North

Practically all the steel now being produced by the Scottish works is against priority orders, and as a result of the curtailment of steel supplies for civilian purposes, deliveries are reaching consumers within reasonable time. The raw materials position in Scotland is satisfactory, and no delays in production have arisen from scarcity in this direction. The call for ship plates, boiler plates, and tank plates is a feature of the market, and although perhaps the pressure is not so severe as it was a month or two ago, it continues to tax the resources of the works. Shipyards in particular are taking heavy deliveries, and locomotive and boiler-makers are also providing a big outlet. Constructional engineering firms in Scotland are not particularly busy, although in one or two cases they have important contracts in hand. This is reflected in the easier demand for the heavier classes of structural joists and sections, but the request for the lighter sizes remains vigorous. The re-rolling works have good supplies of billets on hand, and in most cases fair stocks are available to meet consumers' requirements. The demand for steel bars appears to be growing, and business in the smaller sizes, after being quiet for a week or two, has revived. The re-rolling industry is also experiencing an active demand for strip. In the Lancashire market business in small bars has been fairly substantial, but some of the works are in a position to give early delivery. The pressure to obtain nickel chrome and other alloy steels is unabated, the demand coming principally from the armaments manufacturers. The call for nut and bolt bars is maintained, and, generally speaking, activity prevails at all the bar mills. All the steel works on the North-West Coast are producing at a high rate, and for some weeks now deliveries have been kept to schedule.

The North-East Coast and Yorkshire

Whilst all the steel works are in full operation the demand for finished steel appears to have eased to some extent, and, generally speaking, the works are not being over-taxed. One of the objects of the distribution scheme put into operation by the Iron and Steel Control was to regulate, so far as possible, the demand upon the steel makers, and this has succeeded in its object to the extent that the inordinate pressure by consumers of a year ago is not now noticeable. The demand now fluctuates somewhat, and is more insistent in some departments than in others. The constructional engineers for the most part are less busy than they were in the earlier days of the war, and the demand for structural steel in the shape of heavy joists and sections, which sharply declined a few months ago, has never recovered its former strength. Some of the works producing this class of material could do with more business, although lately there have been signs that consumptive needs may shortly have a tendency to expand. The lighter sizes of structural steel are required in considerable quantities and the re-rolling works are kept busily employed. An active business is passing in steel bars, but there seems to be considerable variation in the times required by different works for delivery. Lately there has been an increase in the demand for large bars over 3in. in diameter, particularly from the enginering firms employed upon war work, which covers the greater part of this industry. Small bars are being turned out in good quantities which pass rapidly into consumption, whilst there is a steady call for reinforced concrete bars. Activity in the plate department continues and the shipyards require large tonnages. This section of the industry is likely to be fully employed for a long time. Production is on a big scale, and the plate mills are pressing their production to the utmost. The expansion in the demand for special and alloy steels is a noticeable feature of the position. The production of steel in Yorkshire is at a high rate. A feature of the market is that the steel works now seem able to quote reasonable dates for delivery, and are not, as in the early days of the war, booking orders for delivery months ahead. There is a heavy production of basic steel, but the demand for heavy structural steel is not more than moderate.

The Midlands and South Wales

Great activity rules in the Midland steel industry, and all the steel works are assured of busy conditions for the remainder of the year. There is a steady flow of orders to the works, but makers are not now booking for delivery months ahead, as was the case in the earlier days of the war, and consumers are receiving much more reasonable delivery. Business in light structural steel is fairly active, and good quantities are passing into consumption, but rather easy conditions prevail in the case of heavy joists and sections, and many of the steel works would be glad to receive fresh business. A feature of the market is the demand for alloy steels. Armaments and munition manufacturers are absorbing large quantities and production has been increased to meet consumers' requirements. It is understood that Russian requirements of alloy and special steels will have to be met, and that as a result this section of the market is likely to be actively employed for a long time. There has been no slackening in the demand for plates, particularly for the heavier thicknesses. The shipbuilding industry and boiler and tank makers are taking up big tonnages, and their requirements are likely to remain on a considerable scale for an indefinite period. There is an increasing demand for steel bars. Re-rollers are experiencing some pressure from the consuming industries for the smaller sizes which are quoted at £17 14s. 6d. delivered London and £17 12s. delivered provinces; the price of tested steel is 3s. higher than these figures. There is a steady demand for bars of 3in. and up, chiefly from engineering works, and business in this description of steel seems to be increasing. The steel works in South Wales are fully employed upon material required for the war. Good deliveries are being made, and most works are able to give fairly satisfactory delivery dates. There is a large production of billets, but the demand for sheet and tinplate bars is rather quiet, and is expected to remain so whilst the restrictions imposed upon the tinplate trade continue in operation. There is a steady home demand for tinplates, but little export business can be transacted, owing to Government restrictions.

Copper and Tin

The copper situation in Great Britain is satisfactory. The Empire supplies arranged for at the outbreak of war appear to be reaching this country with regularity and in sufficient quantities to meet the requirements of the war industries. The Non-ferrous Metal Control carefully supervises the distribution, but there seems to be a gradual tightening up in the position so far as supplies for what is regarded as non-essential work are concerned. It is interesting to note that whilst it has been assumed that the German copper position is difficult, it has been revealed that the Italians are short of copper and that their annual consumption of 80,000 tons is difficult to provide, in spite of a campaign to collect scrap from domestic sources. The United States position is unchanged. There have been no further developments in the policy of the authorities in that country to pay something in excess of the fixed price in order to enable the high cost producers to operate at a profit. It is expected, however, that the policy disclosed by taking over three mines on a cost plus basis will be extended to include others. The fears that were expressed that America would have to go short of copper owing to the heavy demands of the defence programme appear to have faded to some extent, but there is no doubt that it will be necessary for the Americans to squeeze every ton of copper they can from their own producing units, whilst taking considerable tonnages from South America. There has been no change in American prices, which stand at 12c. for the home trade and nominally at 11½c. for export. . . . Quiet conditions have ruled in the tin market, but the tone has remained firm. The latter is probably due to covering operations, which have not been unconnected with Russian purchases. On the other hand, there have been no hedging sales by the smelters, so that buying has been more in evidence than selling. The persistent tension in the Pacific has also influenced the market, since there has been a tendency to cover against any possible interruption to supplies from that part of the world.

Lead and Spelter

The lead position in Great Britain has not altered much, although there appears to have been some tightening in the situation since Russia was forced into the war. Russian requirements are said to be on a heavy scale and large supplies will probably go direct to Russia from Empire sources. Hitherto the lead position has been the easiest of all the non-ferrous metals, and it has been possible to release a fair amount for ordinary civilian consumption. The Russian requirements, however, may change the situation, and it is possible that the quantities available for other than essential purposes may be drastically reduced. It is thought that the Control possesses considerable stocks in Great Britain and that it will be some time before the position becomes stringent. The American lead situation has become distinctly tight and has been rendered the more difficult by a strike at the Mexican mines of the American Metal Company. . . . The spelter situation in Great Britain is rather tight, but although large quantities are passing to firms engaged in the war effort, their needs appear to have been met. The British galvanising industry is also taking good quantities of spelter. In the United States conditions remain tight, although more spelter seems to be available there than lead; whilst the reverse is the case in Great Britain. Supplies, however, are reaching the defence industries in satisfactory quantities.

Notes and Memoranda

Rail and Road

AN UNUSUAL LOAD.—In order to transport a 16in. gun, 68ft. long, from Watertown Arsenal, Massachusetts, to Fort Church, Rhode Island, U.S.A., the authorities constructed a special railway truck. The combined weight of the gun and this 24-wheel wagon was over 200 tons.

THE DOUBLE TRACK ON THE SIMPLON.—Plans for doubling the last 15-mile single-track section of the Simplon line, from Gallarate to Arona, are now ready, and the work is to be taken in hand at once. Earlier this year the Arona and Domodossola section was doubled. The 28 miles between Milan and Gallarate had already been laid.

GERMANY'S SHORTAGE OF PETROL.—It was recently stated in a German broadcast that to conserve petrol for war purposes only lorries propelled by wood gas are now being built in Germany. There are now 500 wood gas producing centres and 700 filling stations in Germany. This year between 2,500,000 and 3,000,000 cubic metres of timber have been used for the production of motor gas.

BERNE'S NEW BRIDGE.—In order to provide a four-track railway crossing over the Aare River, a new reinforced concrete arch span has been completed at Berne, Switzerland. The bridge is about 1 mile in length with the main arch span of 492ft. Prior to opening the new crossing, which is to be known as the Lorraine Bridge, the span was loaded with four locomotive trains, each train consisting of five steam locomotives. The structure was built by the bridge engineering department of the Swiss Federal Railway, at a cost of 14,000,000 Swiss francs.

AUSTRALIA AND ROLLING STOCK.—Australia has shipped some of its locomotives and rolling stock to Iran, and is building or buying more. The programme of the Victorian Government Railways for 1941–42 includes twenty more "K" class 2–8–0 engines, ten more "X" class 2–8–2 engines, and 400 20-ton "G Y" trucks. "No. 169," a new "K" class, has now been turned out, as also have twenty new four-wheel "Z" vans. A further twenty are building. In South Australia the Government programme includes two diesel-electric locomotives. Ten steam locomotives are to be constructed, some of them "Mikados" (2–8–2s) and some of a new design of medium-size "Mountain" (4–8–2) type. Other items are twenty-four new passenger cars, fifty open bogie 40-ton trucks, and 100 four-wheel louvre trucks.

Air and Water

WATER POWER IN SCOTLAND.—The Scottish Council on Post-War Problems has announced that on its recommendation the Secretary for Scotland has appointed a committee to consider (*a*) the practicability and desirability of further development in the use of water power resources in Scotland for the generation of electricity; (*b*) by what type of authority or body such development, if any, should be undertaken. Lord Cooper is chairman and Mr. M. R. McLarty, of 9, Parliament Square, Edinburgh, will act as secretary.

AMERICA DEVELOPS WATER POWER.—At the present time there are under construction in the U.S.A. no fewer than eight major hydro-electric projects. Perhaps the most important of these schemes is that at Grand Coulee dam, where the first 108,000-kW generator was put on the line last month. A second large generator is to be ready for operation in January and a third in 1942. Owing to the intensified development of the electro-metallurgical industry, in the Pacific North-West during the past few months, it has been recommended that installation of fifteen of Grand Coulee's eighteen generators be expedited and that money be made available for their purchase.

ORIGINAL NIAGARA GENERATORS AGAIN IN SERVICE.—To supply power for defence industries, the ten original Westinghouse water-wheel generators at the Niagara Falls Power Company's Adams station, Niagara Falls, were recently put into regular operation after being used only for reserve service for seventeen years. Installed in 1896, the generators, five rated at 4000 kW and five at 3750 kW., were in continuous operation until 1924. Since then they have been held in reserve for standby and synchronous condenser service only. Under a treaty between Great Britain and the United States in 1910 the total amount of water permissible for American diversion was 20,000 cubic feet per second, and this could be used to better advantage by the more modern Schoellkopf station on the Niagara River. With the need for additional 25-cycle hydro generating capacity to supply certain electro-chemical and electro-metallurgical plants at Niagara Falls, an additional 5000 cubic feet per second was granted under an emergency permit from the Federal Power Commission, and the Adams station resumed regular operation. Idle generating capacity still remains at the Adams station. If called upon, more energy can be produced whenever the Federal authority permits further water diversion.

WIND POWER FROM A MOUNTAIN TOP.—As described in an article in our issue of July 18th last there has been constructed on Grandpa's Knob, Castleton, Ut., 2000ft. above sea level, the first wind-operated generator to deliver energy to an A.C. central station power line. The first run was made last month and continued for two hours, during which a maximum output of 800 kW was delivered, the wind velocity indicated by the anemometers at this load being 26 m.p.h. Energy generated at 2300 volts, 60 cycles, is transformed to 44 kV for delivery to the Central Vermont system. The generator speed is 600 r.p.m., and the two propeller blades driving the mechanism have a wing spread of 175ft., the equipment being mounted on a tower about 110ft. high on a mountain summit, about 2000ft. above sea level. The plant is the outcome of 500,000 dollars spent in experimental research.

Miscellanea

PALESTINE GALENA DEPOSIT.—Considerable deposits of galena are reported from Palestine. The finder has obtained a concession for the exploitation of the deposit. Mineral deposits of this kind have not previously been found in this part of the world.

WIDNES FOUNDRY CENTENARY.—The Widnes Foundry and Engineering Company, Ltd., celebrated its centenary this year. The company was founded by Thomas Robinson in 1841, and has been engaged during the past hundred years manufacturing heavy castings for the chemical industry and steel constructional work. The war conditions necessitated curtailment of any special celebrations, but the company organised a meeting for its employees, at which it was announced that the directors had decided to make a gift to every employee of a week's salary or wages. Employees with over twenty years' service, of whom there were sixty-eight, received additional recognition in the form of National Savings Certificates.

CONFERENCE OF INDUSTRIAL SCIENTISTS.—There is said at present to be a widespread feeling that our technical and scientific resources are not being used to their full capacity in the national effort, for lack of co-ordination between various workers, through insufficient responsibility being given to scientists in their specialised fields, and because of grievances, due to irregular conditions of work or employment, which unnecessarily distract a number of scientific workers from their efforts. Believing that scientific workers should themselves set about improving this position, the Association of Scientific Workers proposes to call a series of regional conferences, to which all scientists, engineers, technicians, and laboratory assistants are invited, to discuss their problems. The first of these conferences will be held at the Royal Society of Artists, New Street, Birmingham, on Saturday, December 6th, from 2.30 to 5.30 p.m. Discussions will be opened by Mr. D. P. Riley, M.A., B.Sc., who will speak on "The Responsibilities of the Scientist to the Community"; Mr. J. A. Henley, B.Sc. Eng., A.M.I.E.E., on "The Position of the Scientist in Industry"; and Mr. E. D. Swann on "The *Rôle* of the Scientist in the National Effort."

POTTERY DEVELOPMENTS.—Pottery of a mechanical strength that can be compared in certain respects with that of grey cast iron is helping to solve some of British industry's wartime problems. The Royal Doulton Potteries, after two years' continuous study, have introduced ceramic wares into many new fields. High-grade chemical stoneware can now be used in place of metal for pipe lines and also for packing purposes, either in relatively small units or in bulk. This pottery has certain advantages over the materials in former use. It resists rust and contamination, is capable of being turned to an almost unlimited number of shapes and sizes, and is proof against all corrosive chemicals, except hydrofluoric acid and hot, strong caustic alkalis. Moreover, it is fired in the kilns at such a high temperature—1250 deg. Cent. or more—that, in compression strength, for example, it can be compared, not with the fragile china or earthenware ornaments of the household, but with metals. New applications of ceramic materials have also been introduced in recent months in the following industries:—Textiles, rayon, papermaking, printing, soap, perfumery, cosmetics, brewing, and food manufacture, also in many branches of the chemical, metallurgical and electrical industries. Included in the wide range of British chemical stoneware plant are not only pipe lines and containers, but pumps, tanks, mixing pans, storage vessels, vacuum and other filters, cooling coils, rollers, steam-jacketed pans, agitators, cooling and absorption towers and tile linings.

Personal and Business

MAJOR ANDREW HOLT has been appointed adviser on scrap supply to the Ministry of Supply.

MR. J. RODGERS has been appointed Director of Post-war Planning in the Department of Overseas Trade.

THE ACCURATE RECORDING INSTRUMENT COMPANY has opened a London office at 46, Victoria Street, S.W.1.

MR. P. R. ANGUS has been appointed Chief Mechanical Engineer of the New Zealand Government Railways.

DR. J. L. MILLER, M.I.E.E., M. Amer. I.E.E., by arrangement, has resigned his position as chief research engineer to Ferranti, Ltd., and is joining British Insulated Cables, Ltd., as deputy chief engineer.

MR. ANDREW HOPPER, commercial manager to the Parsons Marine Steam Turbine Company, Ltd., Turbinia Works, Wallsend, during the past five years, has been appointed a director of the company. Mr. Hopper served his engineering apprenticeship with the company, subsequently occupying technical positions in the company's drawing-office and estimating department.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that in order to make sure of its insertion the necessary information should reach this office on or before the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Institution of Automobile Engineers

Sunday, Dec. 14th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. "Design Department," J. B. Perrett. 2.30 p.m.

Institution of Chemical Engineers

Tuesday, Dec. 9th.—Geological Society's Rooms, Burlington House, Piccadilly, W.1. "A New System of Double Filtration for Sewage and Certain Trade Waste Waters," A. Parker. 2.30 p.m.

Institution of Electrical Engineers

Monday, Dec. 1st.—S. MIDLAND CENTRE: James Watt Institute, Birmingham. "The Characteristics and Performance in Service of High-voltage Porcelain Insulators," J. S. Forrest. 6 p.m.

Wednesday, Dec. 3rd.—WIRELESS SECTION: Savoy Place, Victoria Embankment, W.C.2. "The Transmission Characteristics of Asymmetric Sideband Communication Networks," E. C. Cherry. 4 p.m.

Friday, Dec. 5th.—METER AND INSTRUMENT SECTION: Savoy Place, Victoria Embankment, W.C.2. "Maximum Demand Metering—a Study of the Timing and Length of the Integration Period," D. J. Bolton. 4 p.m.

Institution of Mechanical Engineers

To-day, Nov. 28th.—Storey's Gate, Westminster, S.W.1. "Practical Vibration Problems," H. L. Guy. 5.30 p.m.

Tuesday, Dec. 9th.—Central Hall, Westminster, S.W.1. Conference on "Air Raid Precaution Measures and the Engineering Industry." 10.45 a.m.

Institution of Naval Architects

Wednesday, Dec. 10th.—Connaught Rooms, Great Queen Street, W.C.2. Luncheon. 12.45 for 1.15 p.m.

Institution of Production Engineers

Saturday, Nov. 29th.—MANCHESTER SECTION: College of Technology, Manchester. "Surface Finish," G. Schlesinger. 2.15 p.m.

Friday, Dec. 12th.—N.E. SECTION: County Hotel, Newcastle-upon-Tyne. "Drop Forgings," A. Chilton. 6.15 p.m.

Junior Institution of Engineers

Saturday, Nov. 29th.—39, Victoria Street, S.W.1. "The Engineer and the Rest of the World: A Study in Relationships," K. S. Jewson. 2.30 p.m.

Saturday, Dec. 13th.—39, Victoria Street, S.W.1. Presentation of awards and induction of Lord Sempill as President. 2.30 p.m.

Keighley Association of Engineers

To-day, Nov. 28th.—Victoria Hotel, Keighley. "Impact and Notched Bar Testing," C. N. Waterhouse. 7 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, Nov. 28th.—Literary and Philosophical Society, Newcastle-upon-Tyne. "Further Experiments with Models of Cargo-carrying Coasters," F. H. Todd and J. Weedon. 6 p.m.

Wednesday, Dec. 3rd.—STUDENT SECTION: Bolbec Hall, Newcastle-upon-Tyne. Technical films. 6.45 p.m.